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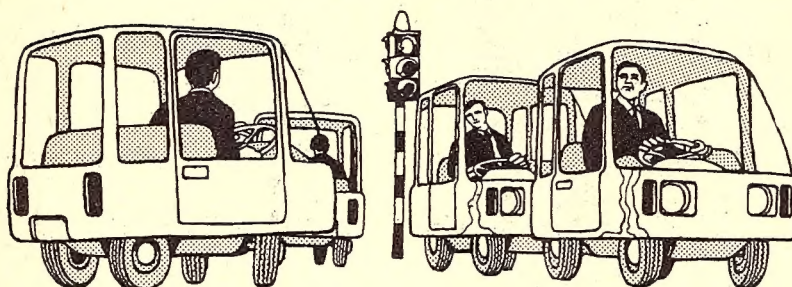
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PROBE

Europe's aircraft effort

Agreement last week by Britain, Germany and Italy on the RB 199 engine for the swing-wing attack aeroplane is a gratifying solution to a situation which had threatened to bring an American engine into a European collaborative project. It had the further welcome effect of giving Rolls-Royce design leadership in the development of an engine which does not yet exist, though both other partners will take a share in this undertaking. What is not yet clear is where the design leadership for the aeroplane will lie. A special company representing the three nations has been set up, with headquarters in Munich and a German chief.

Whether or not this will be allowed to put design leadership into the hands of the Germans is arguable on two grounds. One is that at least as many again of these aircraft may be sold to other nations if the design is a success. The other is that Britain already possesses a large body of design experience in the basic subject of the swing wing, having had work in progress since Sir Barnes Wallis flew his small, swing-wing aeroplanes nearly 15 years ago. That Germany should seek to re-establish her aircraft industry with a major military project is natural and the MRCA presents a splendid opportunity. Unfortunately, German dominance will mean a continuation by Britain of her sacrificial policy at the altar of European aeronautical collaboration. Design leadership has been steadily handed over by Britain to partners on the Continent since she began to aim at entry into the Common Market.

British humility when programmes for the Concorde, the Jaguar, and the European air bus were being formulated has gone far enough. Before last week's engine decision was reached, there had been a long run of Anglo-German cooperation in the design study and an entirely new engine is to proceed from it. In the same period a great deal of preparation had been made in Britain for the airframe of this two-engine, supersonic fighter-bomber-reconnaissance aeroplane along lines which will make it fit for high speeds at low levels to evade the ground defences. The team which produced the TSR2 has moved on to this development of the same tactical requirement. It is probably best suited, among the three partners, to lead in what now remains to be done. The time for genuflecting to continental nationalistic particularism is past. The determining factor now should be the qualifications and technological equipment of the partner selected for leadership. If the MRCA is to be good enough to find a world market, that part of the task should rest with Britain.

Britain's first squatters

Since the middle of June, Dr John Waechter of London University's Institute of Archaeology has been digging at Swanscombe, Kent, in a deposit considered by previous workers to be practically an archaeological blank. Just as he was closing down for the season, he has now struck Britain's oldest living site. Well covered by BBC2 last Wednesday, it has been largely ignored by the press—perhaps because only human skulls make the headlines. Dr Waechter has not yet found the earliest Englishman; but he has the bones of the animals the ancient

Briton ate and the tools he used to skin them and chop them up.

These finds are considerably older than the most ancient Briton known so far, which also came from Barnfield pit at Swanscombe and which consists of an occipital and a parietal bone in 1935-36 and another parietal recovered 20 years later. Swanscombe is Britain's richest prehistoric site, with two industries abundantly represented. The earlier is the Clactonian, named after Clacton-on-Sea, and the later is the Acheulian hand-axe industry. Swanscombe Man, known only from these three skull bones, made the hand-axes and lived during the Great Interglacial, some 250 000 years ago.

At this time a mighty river laid down the so-called Middle Gravels; below them are the Lower Loam and Lower Gravels containing Clactonian implements. These include choppers made on flint cores as well as flakes, but no hand-axes. Up till now, nearly all the Clactonian tools and associated fossil mammals had come from the gravels; the thick loam or clayey sand, which resulted from marsh conditions or ponding, had yielded very little.

Most excavators would have stripped this unpromising material as rapidly as possible to get at the artefacts beneath. But anything found in river gravels is bound to have travelled some way from its original source. Dr Waechter reasoned that somewhere in the Lower Loam undisturbed "living floors", places where men made their tools and ate their food, must exist. Methodically, he worked through the deposit and has been rewarded by the discovery of the only known Clactonian living site.

As Dr Waechter wrote in his report of last year's Swanscombe dig, "The small soundings and limited collecting made in the past are no longer valid. Unless such material is seen in its correct activity context, the collected implements become no more than an unrelated typological series." Only recently have prehistorians begun to look for that kind of evidence, inspired by the results obtained from careful excavations like those of Dr Leakey at Olduvai.

Perhaps with undue modesty, Dr Waechter describes his find as a midden rather than a floor, a place where squatters on the edge of the marsh chucked out their rubbish. There is little difference, however, between the Swanscombe "midden" and the Olduvai "living floors" except in the nature of the menu. The rhino tooth from Swanscombe would not be out of place at Olduvai, but the bear skull, red deer antler and aurochs bones would certainly not be found in Tanzania. Clactonian flakes surround the bones; if this is a midden, why would the cutlery have been thrown out with the remains of the joint? Dr Waechter's explanation is that as a chopper or scraper became blunt, it was easier to make a new one than to sharpen it. With such crude implements, it is unlikely that the Clactonians were efficient hunters. Probably they drove animals into the swamp, or at any rate feasted on them when they became bogged naturally.

Just how much earlier the Clactonians lived than the Acheulians is difficult to estimate. There is an unconformity, a period of weathering, between the Lower Loam and the Middle Gravels which could represent anything up to 100 000 years. The Clactonians probably lived during the first third of the Great Interglacial, the Acheulians during the last third; the middle part is missing.

The excavations have been financed mainly by the British Museum (Natural History) and the British Academy, and are to continue next year. This, if fact, is only a beginning. Dr Waechter is convinced that he is on the edge of the true living site. (After all, he says, they wouldn't have bothered to throw a bear skull very far from where they were camping, it's far too heavy.) Somewhere in Barnfield pit, perhaps next season, he may find the most ancient Briton of all.

Costs of failure

The cost to Britain of failures in machines and components runs at something like £1 000 million a year. According to surveys conducted during National Productivity Year (1962-63), defective manufacture alone, it seems, cost British industry some £400 million annually. The armed forces bear a heavy load because of the combined effects of unreliability and defective quality. In the RAF, the cost of unreliability totals 40 per cent of the annual air estimates. In May 1966 the Fleet Air Arm was spending £50 million a year on maintenance, of which the part due to unreliability came to about one-third. For the National Coal Board, an increase of 15 to 20 minutes each shift in the time that machines are available would improve its finances by £5-6 million annually. Over a wide variety of industry the costs of unreliability are generally 12-20 per cent of the firm's turnover. There are probably many firms in which improvement would double profit, or turn loss into profit.

The Institution of Mechanical Engineers last week gave the matter a much-needed airing at its meeting, at the University of Sussex, on safety and failure of components. It is apparent that if industry would adopt only the existing practice of the best British firms, much of the loss would be cancelled almost overnight. If only managers would realise that they are sowing the seeds of their own ruin by neglecting quality and reliability, and if only designers would listen more to what their customers have to say about the performance of components under working conditions, the position would improve out of all recognition. As yet, the lesson has not sunk in far. A survey of some 2 000 firms—again carried out for National Productivity Year—showed that about a third of them were assuredly losing money and reputation because of inadequate activity on maintaining quality and reliability.

If there is one thing we cannot neglect, this is it.

North sea TV

Last week's news that commercial radio interests plan to broadcast television programmes from an aircraft circling over the North Sea provides the latest example of an airborne TV station—an idea that has been controversial for at least 20 years. The TV "pirates" seem to be confident that they can operate the scheme at a profit, and no doubt in these special conditions they can do so, but most other airborne stations have found it difficult to compete with conventional stations because of the extra cost involved. A survey for India, for example, showed that an airborne scheme would cost 50 per cent more than a ground-based one.

The most successful scheme is that known as the Midwest Programme for Airborne Television Instruction in the US, which was started in 1961 and ended last year because of "political factors". This station broadcast 17 half-hour courses, of elementary, high school, and college level, from a DC6 aircraft flying a figure-of-eight pattern at a height of 23 000 feet above Montpelier, Indiana. The plane had to maintain its altitude and position within fairly narrow limits so that simple directional aerials of a conventional design could be used on the ground. A specially designed computer was installed in the aircraft to process the signals from standard radio navigation stations to give the pilot continuous information on his position. The pirates will no doubt be able to rely upon standard Decca Navigator equipment. A special gyro system also had to be fitted to the MPATI plane. This sensed the degree

of bank along the flight path and operated an hydraulic system which kept the 24 foot aerial vertical, so that the radiation pattern and polarization of the signals could be kept constant. This was said to be essential to keep the power in home receivers at an adequate level over the ground service area, which had a radius of 200 miles. Transmissions were in the 815 to 850 megahertz band. The new UK pirates apparently intend to broadcast in the same part of the spectrum as BBC 2, which is in a lower-frequency part of the ultra-high-frequency band.

The pirate stations, following the same approach as the American plans, will broadcast programmes recorded on film and videotape, and will carry a simple camera system for station announcements and the usual disc jockey type of chat. Quite apart from the government ban, live broadcasts relayed from the ground would probably be ruled out because of the need for highly accurate, and therefore very expensive, tracking equipment to keep the radio beam from the ground station pointing at the nose of the aircraft as it flies around.

The pirate TV station will, of course, have many other problems to contend with. Its home base may be some distance away, and there is the problem of interference caused by, and affecting, the pirate station. It is always extremely difficult to decide between the conflicting claims on this subject. The commercial broadcasting interests usually say there will be no interference, while the authorities claim it will be very high. A classic example of this arose during discussions on the possibility of having local radio stations in the medium-frequency band. The Postmaster-General said that there was room for only one-tenth of the number of stations that the commercial interests said they could provide. Both sides were obviously overstating the case, which makes it very difficult to judge the accuracy of their statements when a new issue such as pirate TV arises. However, all the indications are that interference will not be a serious problem.

No time for despair

With the troubled but endearing air of a country clergyman who has just added another foreign mission to his list and doesn't know whether the congregation will wear it, the director of Oxfam includes in his annual report the information that at the end of the financial year the organization had allocated £489 871, in excess of funds available, to projects throughout the world. "Consequently the bank and other deposits are completely exhausted." But not, one might add, the energies of Oxfam's devoted collectors. Though times may be relatively hard for Britain—or seem to be so—there is little doubt that Mr Kirkley will get his money.

Oxfam's income has been increasing each year at the rate of £250 000. And, what is more encouraging, there is evidence that contributions are coming in from a broad section of the community—a sign that Oxfam's brilliant propaganda is lighting the imaginations and touching the hearts of people unaccustomed to considering problems outside their own immediate interest. In this connection it is interesting to study the figures produced by the Education Unit of the Freedom from Hunger Campaign, which surveyed the syllabuses and papers of all the examining boards (CSE and GCE) in the United Kingdom. It found, gratifyingly, that every board had some reference to problems of world poverty and development. In the struggle of the aid agencies to overcome public apathy, the effect of continuing education cannot be overemphasized. It might seem that the need for urgent *national* action has already been spelt out. The world population explosion is becoming a subject

for black humour. Statistics of despair eventually numb the conscience. Scientists in this field, driven by the logic of their studies, might sometimes be little more restrained in their published predictions, especially when, as in some papers there is an underlying implication that disaster is certain. Better to plough on with Oxfam and its like, whatever the odds.

The biggest task is to persuade whole nations to ignore self interest and voluntarily restrict material progress until justice has been done to the world's poor. At this time—even in the year when Man first set foot on the Moon—the task may seem as impossible as ever. Aid programmes are actually being cut. Speaking to the Oxfam staff earlier this year, the honorary Secretary, Dr F. C. Cyril James, said, "This challenge is almost beyond imagination, but so was that which faced the men and women with liberal ideas in Britain a century ago." Although the problem is often pictured as primarily technological—the modernization of agriculture coupled with birth control programmes—it is in fact a moral one. Not all the squirmings of pragmatic politicians can disguise it.

What price a PhD?

Anguished doubts were expressed at the Exeter meeting of the British Association on Tuesday about the utility of the PhD for chemists. Apart from argument about how good a training PhDs receive, discussion was concerned with their immediate job prospects. Briefly, the statistics suggest these facts. Chemists at the end of their first degree are likely to want to continue to a further degree—and many do so. Chemistry and biochemistry are the subjects in which the highest proportion of graduates continue to further academic study; in 1970, some 1200 chemists will finish higher degrees in chemistry. What will they all do?

In the past, universities have employed many, and others have taken post-doctoral appointments, mainly as a temporary expedient. At a time when universities have stopped expanding in numbers and are being examined ever more critically for cost-effectiveness, the number of chemists required annually as university lecturers is drastically smaller. Authoritative estimates put the number at about 30. On past trends, industry in the United Kingdom may be expected to take perhaps 250, government research 30, schools and colleges of further education 150. Some chemists with higher degrees will return to foreign countries, or be employed already, while some (female) chemists will simply retire to raise children.

There will remain, however, 500-600 chemists with higher degrees who will expect to continue in research but will have severely limited opportunities for doing this. Their obvious courses of action are to take a post-doctoral post, to emigrate or to find employment unconnected with their specialist research training. It may well be that the appeal of post-doctoral appointments will diminish, as they can no longer be looked upon as a short term stint leading subsequently to a university appointment. Emigration is likely to remain high, and even grow unless restrictions in the United States and over-production of higher degree chemists in other countries prevent this. For the chemist, the decision to continue with research in university may considerably increase the chance of his subsequently emigrating.

If these figures are anything like correct, something must give. University chemistry departments maintain flourishing research by being able to use the work of more than 3000 research students. But it may well be that it is more expensive in the long run to rely on such slave labour than to employ technicians, for the hidden costs may increasingly include the unhappiness of a sizeable proportion of higher degree chemists, who find it

difficult and perhaps impossible to fulfil their ambitions to do research.

Perhaps the most helpful change would for more chemists to recognize that a first degree in chemistry can lead the able into worthwhile careers other than those based on chemical research. From the individual's, as well as the national, point of view, it is clearly important that able chemists should find rewarding tasks in British industry. Their most important contribution is unlikely to be based on research alone. Chemists acting as maids of all work, posing their own problems as well as solving those flung at them, are likely to make the biggest impact. There is often little in their degree course to encourage this sort of colonizing activity; perhaps *force majeure* will prevail.

AND THE LAST WORD . . .

On plate-smashing

Wherever their political sympathies may lie, it must be aurally disappointing for visiting lovers of Greece to find that the *tavernas* no longer resound to the rapturous clatter of breaking crockery. When other, younger nations clap, whistle or stamp their feet in approbation, the Greeks choose to show their appreciation of *bouzouki* music and cabaret performers by smashing plates on the floor. Night club performers measure their success, not by decibels of applause or numbers of curtain calls, but by the depth of the shattered chinaware about their feet. But this year, the carefree *rallentando* has been heard no more. Premier George Papadopolous has decreed that plate-smashing in public is a "barbaric custom" and has banned it, together with long male hair and short female skirts, under his puritan regime.

Smashing glass and crockery has long been popular with the human race as an outlet of high jubilation or emotional pressure. At Jewish weddings, glasses are crushed under bridegroom's heels. Russians are wont to hurl their vodka goblets into the fireplace after special toasts. In Britain in the early nineteenth century, parties bent on serious conviviality would break the stems off their glasses so that they could not be stood down again, and all refills would have to be drunk without heel-taps. At Hogmanay in Scotland it is sometimes hard to hear the words of Auld Lang Syne for the shattering of the tumblers; and at Glasgow football matches, the referee's whistle can often be inaudible under the rataplan of fractured bottles. The standard emotional release for vexed wives has ever been the hurling of the second-best china at the nearest available husband or wall. And there are few side-shows at garden parties more popular with males than the crockery-smashing stall where you win no prizes but get the blessed release of letting off steam.

Premier Papadopolous may perhaps be crossing a small Rubicon in depriving his exuberant compatriots of their particular sublimation of this human urge to iconoclasm. The *taverna* proprietors are already pretty fed up about the ban, since selling crockery to customers at up to a dollar a throw was a profitable sideline. Expendable crockery manufacturers are at loss for a new market. *Bouzouki* musicians are also disgruntled, since unemployment threatens because the smaller night clubs used to pay the band out of their takings on plate-smashing. It is rumoured that frustrated Greeks are now so put out by the puritan decree that they go home after a night out and hurl their own china against their private kitchen walls. And the colonels might mark well the command of that Greek popular song which urges revellers to "*Ola spasta, ola kapsta*" which means "Smash all, burn all", and reflect that if their subjects are kept too long from the former, they may well decide to take up the latter.

MONITOR

EDITED BY GRAHAM CHEDD AND DR PETER STUBBS

Quarks detected? Well, maybe

Professor Charles McCusker of the University of Sydney created quite a stir in Budapest last week by announcing at the 11th International Conference on Cosmic Rays that he had detected cosmic ray particles of fractional electric charge—a property of the “quark” which has been suggested as being the building block of elementary particles. But a critical analysis of his evidence by other experts at the conference casts doubts on McCusker’s claims. From 60 000 tracks photographed in four Wilson cloud chambers at sea level, five tracks exhibited characteristics of fractionally charged particles, but these tracks may be spurious events of known elementary particles.

McCusker used an array of Geiger counters and scintillators to activate the cloud chambers for cosmic rays of 4×10^{15} eV energy. The charge on the particles was determined by measuring the density of the droplets formed by primary ionization of cosmic particles in the chamber. Since the droplet density is proportional to the square of the charge, particles with $\frac{2}{3}$ electric charge (a predicted property of quarks) would produce $\frac{4}{9}$ of the primary ionizations caused by a particle of unit charge. In the five anomalous tracks, the droplet density was about half of that for the other 60 000.

However, the droplet density can fluctuate

from other causes such as variation of the particles’ velocity and secondary ionization effects. Most experts agree that high-energy cosmic rays are the most likely source of quarks, but they think that McCusker did not account for all spurious events, and place the confidence level on his discovery at about 10 per cent.

Hybrid cells immunize against cancer

As Dr Eric Sidebottom pointed out in *New Scientist* last week (see “Cells with Two Masters”, vol. 43, p. 470), the technique of cell fusion pioneered at the Sir William Dunn School of Pathology at Oxford by Professor Henry Harris and Dr J. F. Watkins, is paying handsome dividends in cancer research. Just a few weeks ago, Harris and his colleagues at Oxford and the Karolinska Institute in Stockholm demonstrated that by fusing highly malignant mouse tumour cells with normal cells, the malignancy could be suppressed (see “Monitor” vol. 43, p. 223). Now Dr J. F. Watkins and another of the Oxford workers, Dr L. Chen, have shown that by fusing the same malignant tumour cells with hamster cells, and injecting the hybrid into mice, the animals can be successfully immunized against later “infec-

tion” with the tumour. Watkins and Chen also claim that the technique can readily be applied to human tumours, and might immunize a cancer patient against his tumour (*Nature*, vol. 223, p. 1018).

There is growing evidence that certain tumours are recognized as “foreign” by the host body, and elicit an immune reaction against themselves in much the same way as do transplanted organs. Unfortunately, the antigens carried by the tumour cells are very weak, and so is the immune response. The tumour therefore manages to survive and also cannot readily be immunized against. In the course of their studies at Oxford, Watkins and Chen succeeded in preparing a hybrid between the mouse tumour cells—Ehrlich ascites tumour—and hamster cells that had been transformed with a virus. As Dr Sidebottom mentioned in his article, a hybrid cell of this type carries upon its surface the antigens of both its components. The Ehrlich ascites/hamster hybrid should therefore carry hamster antigens, and injecting them into mice should certainly elicit a strong immune response, rejecting the hybrid. It occurred to Watkins and Chen that by rejecting the hybrid cells because of their hamster antigens, the mice might also become immune to the Ehrlich ascites antigens carried on the surface of the hybrids. Their guess turned out to be correct.

When injected into mice, the hybrid appeared to gain a slight foothold at first, but by the end of seven days all the hybrid cells had completely disappeared. An injection of 10 million hybrid cells was completely cleared by the end of the week. Obviously, the hamster antigens were eliciting a very strong immune reaction, for even animals that had received radiation to depress their immune response were in most cases able completely to reject the injected hybrids.

Ten days after injecting five groups of five mice with one million hybrid cells, the animals were challenged with an injection of Ehrlich ascites cells. Each group received a different dose of tumour cells: the highest was one million, and the other groups received ten-fold reductions down to 100 cells. A control group of mice, who had not previously been injected with the hybrid, were already known to have an LD₅₀ of 10 tumour cells—in other words, an injection of ten cells led to lethal tumours in half the mice. For the experimental animals, the LD₅₀ was around 100 000 tumour cells. Immunization had thus increased the LD₅₀ by a factor of about 10 000; put more colloquially, the mice were some 10 000 times more able to resist the cancer after the immunization procedure.

The mechanism of this apparent immunization is still obscure, but the experiments show beyond doubt that by strongly provoking the immune system with antigens of a different species, it can be alerted to weak antigens which normally would fail to elicit a response. The provoked immune system learns to recognize antigens which normally escape its notice. If Watkins’ and Chen’s optimism as to the possible therapeutic use of similar hybrids to jar the immune response into action against human cancers is justified, then a new chapter in cancer therapy may be about to begin.

Lunar rocks about to go further

Lunar samples from the *Apollo 11* landing are due to be released to the 140 investigating laboratories tomorrow, 12 September. By last Friday (5 September) preliminary analyses at the Lunar Receiving Laboratory were reported as being “virtually complete”. A final report was expected to go to the Interagency Committee on Back Contamination in the middle of the week. The only possible hitch might come from the Plant Pathology Group, as a result of a report that plants grown on lunar dust were greener and harder than control plants. The result is still unexplained. Dr Walter Kemmerer, in charge of all biological testing at the LRL, said in a telephone interview last Friday that “there are no abnormalities in any of the species under test at LRL which would preclude the release of the samples”.

The main scientific discussion at the LRL and at the Manned Spaceflight Center continues to be around the great age of the lunar material (see last week’s “Monitor”, p.462), and the expectation that rocks in the lunar highlands could be as old as the solar system itself. The first landing on an upland area is scheduled for *Apollo 13* in March of next year, though the landing which is most likely to yield a piece of primordial material is not due till *Apollo 16* touches down in the South Central Highlands early in 1971.

The results from the seismometer left on the Moon have been inconclusive. Three events were recorded early which were put down to moonquakes or meteor hits, but they have not been repeated and Dr Gary Latham, in charge of the experiment, now feels that “something funny happened to the electronics”. He believes, however, that the interior of the Moon is not like that of Earth. “Either there are no major seismic sources on the Moon”, he said, “or else it is a very heterogeneous body”.

Unofficial discussion still concerns the rift that has developed between NASA scientists and engineers. Dr Wilmot Hess, who last week left his post as Director of Science and Applications at the MSC, expressed himself disappointed over the lack of scientists due for lunar landings. The first scientist astronaut may be included on the *Apollo 16* mission.

The nuclear membrane does more than wrap up the genes

An unusual part of the living cell has been in the scientific news recently — the nuclear membrane. It is unusual not because it is rare or unimportant, but because very little is known about it. Now a couple of papers have added a little more knowledge.

The nucleus is divided off from the rest of the cell in higher, so called eukaryotic, organisms by two membranes. Under the electron microscope, each of these looks like the standard membrane used to build up a number of subcellular structures, and to surround mitochondria and the cell itself. Inside the nucleus is the main body of the cell's DNA. Messenger RNA is made there and ferried out into the cytoplasm to direct protein synthesis.

Obviously the nucleus is a specialized organelle for storing genetic information and controlling its expression. But Max Alfert and Nirmal Dal, of the University of California at Berkeley, think that the nuclear membrane has a special role to play. They report in the *Proceedings of the National Academy of Sciences* (vol. 63, p. 123) how they measured the rates of DNA synthesis in cells containing different amounts of DNA. It might be expected that the rate would be proportional to the

volume of the nucleus (as indeed was the rate of RNA synthesis); but in fact the rate of DNA synthesis turned out to be proportional to the *surface area* of the nucleus.

This result could be explained if DNA synthesis is limited by the speed at which a vital intermediate is transported across the membrane. But Alfert and Dal prefer another theory. They suggest that each chromosome is attached to the nuclear membrane—in rather the same way that a bacterium's DNA is attached to its outer membrane—and that this attachment controls the replication of the DNA in the chromosome.

A test of this theory may become possible as a result of the work of David Kashnig and Charles Kasper of the University of Wisconsin, who have developed a method for isolating pure nuclear membrane from rat liver. Essentially their method depends on separating membrane fractions of different density. They describe in the *Journal of Biological Chemistry* (vol. 244, p. 3786) how they found equal amounts of two membrane materials, which were chemically quite distinct and had quite different enzymic contents.

Electron microscopy has shown that the outer membrane of the nucleus is continuous with the endoplasmic reticulum (a system of tubes and membranes extending throughout the

cytoplasm) and Kashnig and Kasper showed that the enzymes on the endoplasmic reticulum were like only one of two nuclear membrane fractions they had isolated. In this respect nuclei appear to be like chloroplasts and mitochondria, which also have different inner and outer membranes.

The Wisconsin workers also found a new non-lipid phosphorus compound in one membrane fraction, which may perhaps be a new species of RNA. But most interesting of all were their findings about nuclear pores. These are the holes through which, presumably, messenger RNA escapes from the nucleus into the cytoplasm. From the side they were seen to be places where the two membranes came together and fused into one layer, while from above they looked like round complexes, about 750 angstroms across, with a definite organized structure. Perhaps they play some sort of "door-keeping" role.

Mitochondria and chloroplasts and nuclei are all beginning to have remarkable similarities. It would undoubtedly be carrying the evidence too far to suggest that maybe they are all built upon the same plan and have become specialized for the tasks of energy generation, photosynthesis and genetic storage respectively. Nonetheless, it is a speculation that may prompt some intriguing experiments.

Mpemba's ice cream explained by computer

The question of whether hot water freezes faster than cold has apparently been asked in Canada for far longer than refrigerators have been known in Tanzania (see "Monitor", vol.42, p.515). The problem has now been tackled scientifically using simple thermodynamic principles by C. S. Kell of the Division of Applied Chemistry, National Research Council in Ottawa. Apparently the Canadian folklore that skating rinks should be flooded with hot water because it will freeze quicker, or that a bucket of hot water left out in freezing weather will freeze quicker than one filled with cold water, can be explained by considering the evaporation of vapour from the water surface (*American Journal of Physics*, vol.37, p.564).

Any covered container will cool according to Newton's law of cooling, so that of two vessels the cooler will remain cooler to the freezing point as they both follow the same cooling curve, and will finish freezing first. When considerable evaporation can take place, however, it becomes the overriding factor in the cooling process when the starting temperature is high. In this way the hotter vessel may diminish its mass enough to compensate for the greater temperature range it must cover to reach freezing conditions.

Kell has developed this principle in both a computer calculation and through a simple experiment using open-necked vacuum vessels. Both agree, and indicate that

there is a maximum time to freeze totally when the starting temperature is at 23°C—which happens to be about room temperature. A vessel initially either above or below this temperature will freeze more quickly; boiling water, for instance, freezes in 90 per cent of the time taken for an equal volume starting at room temperature.

In freezing ice cream, the problem which created the recent Tanzanian question on this topic, the situation is complicated by heat conduction to the freezer compartment of the refrigerator. Not only this, but a lower thermal resistance is probably formed between the hot vessel and the floor of the compartment as a result of the melting of the ice-layer there. This means that the latent heat of fusion of the vessel is conducted away more efficiently than would be the case for a cold vessel placed in the ice-making compartment.

When chemistry affects radioactive decay

When radioactive decay was discovered at the turn of the century, physicists were amazed that the half-life of a nucleus was independent of temperature and chemical composition. Today, nuclear physicists commonly assume that nuclear properties do not depend on the physical or chemical state of the radioactive nucleus. But now it appears that those earlier physicists may be having the last laugh, for it has recently been emerging that under some circumstances decay lifetimes *can* be significantly modified by the effects of neighbouring atoms.

This effect occurs when the transition energy between two nuclear levels is especially low. In these cases the emission of a gamma ray is usually inhibited and the nucleus can instead transfer its decay energy to an orbital electron, which is then ejected from the atom. And the availability of these so-called conversion electrons is affected by the chemical environment of the radioactive nucleus.

The nucleus uranium-235 was recently studied by M. Nève de Mévergnies of the Centre d'Etude de l'Energie Nucléaire, Mol-Donk, Belgium (*Physical Review Letters*, vol.23, p.422). Uranium-235 possesses a nuclear level with an energy less than 100 eV above the ground state

level, and a lifetime of about 26 minutes. This long-lived uranium-235 level can be easily populated from the alpha particle decay of ²³⁹Pu.

Nève de Mévergnies placed a thin layer of ²³⁹Pu near various metals, allowing the daughter nucleus, uranium-235, to recoil into the metallic lattice before half-life observations were made. Electronic measurements showed a significant variation in the lifetime from metal to metal. The shortest half-life (25.52 ± 0.23 minutes) was observed in vanadium and the longest (26.98 ± 0.22 minutes) was in gold. Intermediate lifetimes were observed in platinum, nickel and copper.

Where have all the distant quasars gone?

All 150 or so known quasars have redshifts (denoted by z) ranging from 0.06 to 2.38, and theorists have tried every possible trick to squeeze out some kind of connection between their own pet theory and the number of quasars with a given redshift. Hopefully, studies of this type will eventually lead to results of cosmological significance. Two facts about quasar redshifts that cry out for explanation are the large fraction clustered around $z=2$, and the apparent cutoff in the distribution beyond $z=2$. Dr Martin Rees of Cambridge's Institute of Theoretical Astronomy now suggests that the absence of quasar redshifts substantially larger than $z=2$ may indicate the presence of an absorbing intergalactic gas (*Astrophysical Letters*, vol. 4, p.61).

Suppose the density of quasars increases rapidly with higher redshift: as we look deeper into space (that is, to areas with bigger redshift) we are also going back in time, and examining earlier epochs in the universe. Perhaps there were many more quasars in the early universe. Taking this view, we expect to see the number of objects with given z to grow rapidly as z increases. This certainly happens until we reach $z=2$, but after that there is virtually nothing. If absorption of quasar light by intergalactic hydrogen is important beyond $z=2$, then the quasars further out will be invisible.

Great efforts have been made to detect intergalactic hydrogen, and its existence and properties are hotly debated (see, for instance, last week's "Monitor", p.366). All attempts to

detect it have failed. But Rees puts forward a simple explanation: the young universe (at large z) contained hydrogen formed by proton-electron recombination after the primeval Big Bang. Quasars and radio galaxies form in this environment, but their light is absorbed by the atomic hydrogen. In older parts of the universe, at z less than 2, the hydrogen has all been ionized into a hot sea of electrons and protons by the quasar radiation. This hot intergalactic medium does not absorb any more light.

Thus the effect which the astronomer observes is a rapidly increasing density of quasars out to $z=2$, followed by a steep decline as he peers into distant parts of the universe where atomic hydrogen still absorbs the light.

This theory has several attractive features. Firstly, if earlier epochs of the universe are characterized by a great abundance of quasars, it is natural to ask what they turn themselves into. It seems likely that after the first stage of evolution they become radio galaxies: both objects are very similar when looked at with radio telescopes. The principal difference is that one is associated with peculiar and elliptical galaxies, and the other with brilliant star-like (hence quasi-stellar) objects. Seyfert galaxies, with their bright nuclei, may form a missing link between the two.

Perhaps the next stage of evolution turns the radio galaxy into a normal spiral or elliptical. Dr Donald Lynden-Bell of the Royal Observatory thinks that our own Galaxy has a quasar remnant at its centre (*Nature*, vol. 223, p.690). The galactic centre is odd in many respects—heavily obscured, and a strong infra-red and radio source. Maybe all the galaxies were once quasars in some distant epoch.

A second feature of Rees' theory is that it suggests a way in which intergalactic gas could be detected. Objects just beyond $z=2$ would appear red, owing to heavy absorption by the atomic hydrogen, and would escape classification as quasars. Several radio sources in the Cambridge catalogues have faint red stars close to the radio source positions. Spectra of some of these will reveal if they are really distant quasars. The detection of a very red quasar would be of great cosmological importance. It would provide convincing evidence that the large redshift really does indicate correspondingly large distances, and it would also give the first positive evidence that there is an intergalactic gas.

Meanwhile, the redshift/distance relationship of quasars has received convincing support from another quarter. Dr J. N. Batcall and Professor Martin Schmidt, of the California Institute of Technology, and Dr J. E. Gunn, of Princeton University Observatory, have recently found five quasars actually lying within nearby clusters of galaxies (*Astrophysical Journal Letters*, vol. 157, p.L77). The redshifts of both quasars and their associated galaxies turn out to be closely similar. In one case, four galaxies with an average redshift of 0.0949 are seen to be physically associated with the quasar B264, which has a redshift of 0.0953—pretty conclusive evidence that the redshifts of both arise from the same physical process. There is little doubt that the redshifts of galaxies have a simple doppler origin. Even this one observation must go a long way to convincing cosmologists that the quasars with larger redshifts are indeed at immense distances from us.

Migrating birds have precise winter quarters as well as a summer home

Birds that are summer visitors to Europe have long been known to return year by year to the same locality or even to the same nest-site, often after a journey of thousands of miles. Large-scale ringing, first in Britain and then elsewhere in Europe, has proved what at first was a matter of anecdote. The development of ringing schemes in Africa south of the Sahara is now confirming what African ornithologists have long suspected: that many trans-Saharan migrants return to the same winter quarters every year. Until recently perhaps the only evidence was the recurrence of a cake-eating yellow wagtail in the garden of Government House in Entebbe in the '30s. Now a paper by R. E. Moreau in *Bird Study* (vol. 16, p.108) provides detailed data from Nigeria, East Africa, Zambia and South Africa which are an astonishing tribute to the navigational abilities of small passerine birds.

At Kano in Northern Nigeria, out of some 10 000 yellow wagtails, mostly of a race which breeds from southern Scandinavia to the Pyrenees and the Urals, 248 have so far been retrapped in their first subsequent winter, 97 in their second, 23 in the third, six in the fourth, two in the fifth and one in the seventh. Figures for other species include two out of 90 redstarts and nine out of 200 sedge warblers. In East Africa recoveries of reed warblers (16 out of 120), sedge warblers (11 out of 129) and yellow wagtails (152 out of 6612 ringed) have been even higher, and many waterbirds have also been retrapped. Deeper into Africa, wood sandpipers, sedge and reed warblers have been recovered in Zambia after a double migration.

In Cape Province, out of over 6000 swallows ringed, 11 have been retaken in subsequent winters, six exactly where first ringed and five within 30 miles. In the Transvaal results are the same: 33 500 ringed, 44 recaptured precisely on station and another 12 within 40 miles (a distance that has been shown to be within the range of daily

movements there). Where these birds had been in the interval is uncertain: South African-ringed swallows have been found breeding from Ireland to 93°E in Siberia.

Enough evidence exists (notably ringing results from the Gabes oasis in southeast Tunisia) that birds wintering in west and central Africa fly over the Sahara virtually without stopping. Since many have airspeeds under 25 mile/h, they must travel night and day, using different celestial clues and navigational systems as they become available. This is the more remarkable when it is realized how rapidly conditions have changed for some species. Five thousand years ago the Sahara was so much less desert-like that it would not have presented the uninterrupted hazard to the migrating birds it does today.

The high recovery rates—for instance, the 13 per cent for reed warblers in East Africa—are the more notable when it is remembered that all ringing stations in Africa are amateur and therefore operated spasmodically; that the population initially ringed includes not only wintering birds but those on their way to localities further south; that birds wander at least a few miles around their wintering sites; and that there is a mortality among adults of around 50 per cent between seasons. Viewed against these considerations, Moreau's paper suggests that many birds migrate annually between a precise breeding site in Europe and equally precise winter quarters in Africa, navigating in each direction many thousands of miles over seas and deserts. Bird migration has tended to be seen in the past as essentially random dispersal southwards, followed by an accurate homing the following spring. This concept must now be replaced by a repeated two-way navigational feat comparable to that of an international airline pilot flying "blind".

GEORGE KENT

**“The current year will be good,
and subsequent years better.”**

Highlights from the Annual Review 1968/69 by Mr. Rodney Kent, Chairman.

Sales £34,228,000
Sales to customers abroad £16,088,000
Net profit before tax £1,847,000

The Group made further important acquisitions during the year. The most notable was Cambridge Instrument Company which significantly adds to the Group's strength in industrial and analytical instruments and gives the Group an important place in the market for advanced scientific and medical instruments.

Prospects

Profits in the current year are expected to be between £2.6m and £3m. This substantial increase reflects both the improved level of demand in many of our markets and also the strengthening of the Group's organisation structure and management.

All parts of the Group operate in growth markets. Every division has exciting opportunities at home and abroad. We believe the existing Group can expect to double its turnover within five to seven years. We are confident that the improvements we foresee will enable the Group to finance growth mainly from within.

In short, there is great confidence in the future.

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Self-control for enzymes

All enzymes have an active site, where the molecule they work upon is bound. But some enzymes can apparently bind molecules at other sites, changing the activity of their catalytic site. Allosteric enzymes such as these are the subject of great debate and intense research, for they allow extraordinarily subtle feedback control in living cells

Dr David Weitzman

is a lecturer in the biochemistry department, University of Leicester

Exploration of the intricate chemical workings of living cells has rewarded biochemists with a detailed picture of the pathways of cellular metabolism. The charting of these pathways results in maze-like diagrams, called "metabolic maps", which tell us much about the numerous chemical transformations going on within the cell, but whose complexity suggests chemical chaos rather than the order which we observe is a characteristic of life. Clearly, delicate control mechanisms must be superimposed on this chemical maze in order to coordinate and balance the various pathways. To maintain a balanced economy a cell must be organized to undertake particular reactions only when necessary, and then only at a controlled rate and to a controlled extent.

Within the last ten years, it has become recognized that an important aspect of metabolic regulation is the control of the catalytic activity of key enzymes, and many cases of enzymes subject to some type of feedback control have been discovered. In general, it is the *initial* enzymes of pathways which are the targets for feedback control by the end-products of those pathways, or by other key metabolites acting as signals to slow down or speed up the catalytic rate of the enzymes. Thus, in a pathway leading from A to P through a series of intermediate compounds, each step being catalysed by a particular enzyme, it is the first enzyme E_1 , which is sensitive to the levels of P, the reaction being slowed down when the concentration of P rises, and speeded up as the level of P falls (see Figure 1). This effect on the first enzyme brings the whole production line under control, and P can regulate the rate of its own synthesis and prevent any wasteful over-production.

The chemical structure of the regulating molecule (or *effector*) is invariably different from the chemical structure of the molecule the enzyme actually works upon (the *substrate*). This dissimilarity led to the idea that the active site of the enzyme—that is, the site where catalysis of the substrate takes place—is distinct from the site at which the effector attaches to the enzyme. Dr Jacques Monod and his colleagues at the Pasteur Institute, Paris, introduced the name *allosteric* (literally, "other site") to describe such a situation. They proposed that the attachment of effector to enzyme is accompanied by a conformational (shape) change in the enzyme molecule, with a consequent deformation of the active site (see Figure 2). Through popular use, the concept of allostery has become somewhat ill-defined. But, perhaps for this very reason, it has prompted intensive and varied research in many laboratories into the nature and mechanism of enzyme control. In this article I shall describe some of our research on the enzyme citrate synthase which illustrates the

salient features of this type of study and of allosteric systems.

Occupying a central and dominant position on a metabolic map is the Krebs cycle (see Figure 3), which plays a major role in energy metabolism. The initial step in the cycle is the condensation of oxaloacetate with an activated acetyl group (in the form of acetyl-coenzyme A) to form citrate, a reaction catalysed by the citrate synthase. In later oxidation steps, hydrogen atoms are taken up by the acceptor molecule NAD to form the reduced NADH. The subsequent re-oxidation of NADH to NAD is coupled to the formation of ATP (adenosine triphosphate—the source of energy for the cell's various activities) from AMP (adenosine monophosphate), NADH is therefore a key intermediate in the transformation of energy from food into ATP, and might be expected to play an important role in regulating such transformation.

Our first studies were carried out on the common bowel bacterium *Escherichia coli*. The citrate synthase of this organism proved to be strongly inhibited by NADH, showing that the phenomenon of end-product regulation of an initial enzyme is applicable to cyclic, as well as linear, pathways. Other bacteria showed similar NADH inhibition. A variety of chemical treatments—such as alteration of the ionic environment, or blocking of the SH groups—results in "desensitization" of the enzyme to NADH. In other words, the enzyme can be treated to destroy its sensitivity to the inhibitor without affecting its catalytic activity. Such desensitization, which is a common property of regulatory enzymes, indicates that the catalytic and regulatory sites are not identical, and justifies the term allosteric.

Some of the bacterial species we examined showed not only inhibition by NADH, but also an opposing reactivation by AMP. While NADH may be considered a "high energy signal" (since its oxidation produces ATP), AMP is a "low energy signal", and indicates a depletion of the cell's energy store. Thus while some citrate synthases are controlled by an NADH "brake", others come under the dual control of an NADH "brake" and an AMP "accelerator", much as the speed of an automobile may be adjusted by a balance between these two controls.

These dual-controlled citrate synthases show a response to both NADH and AMP which is sigmoid, or S-shaped, (see Figure 4). A sigmoid dependence of activity on substrate or effector concentration is a common characteristic of allosteric enzymes and contrasts with the hyperbolic kinetic relationships found with the majority of enzymes. The sigmoid curve suggests that more than one molecule of substrate or effector reacts with the enzyme and that the binding of one facilitates the

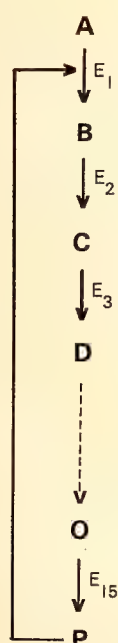
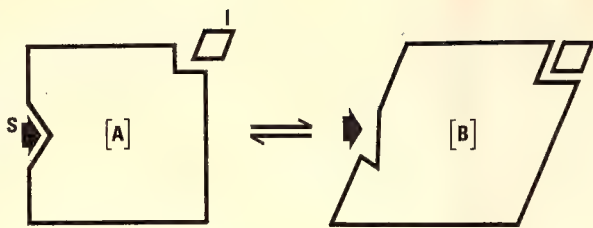


Figure 1 The end-product, P, of a chain of enzymic conversions from A can control its own rate of production by affecting the activity of the first enzyme in the chain, E_1

Figure 2 Diagrammatic representation of a molecular conformational change. In conformation A, the enzyme can bind substrate S at the active site and exhibit catalytic activity. In B, the binding of inhibitor I changes the enzyme's conformation, producing a deformation of the active site, and inhibiting the enzyme's activity. Allosteric enzymes contain several sub-units, and conformational changes of this kind may be relayed throughout the molecule



binding of further molecules. There is, in other words, some kind of cooperative effect in action. The molecular basis of this cooperativity is not yet known, but all models proposed for allosteric behaviour seek to explain these unusual kinetics. (Indeed, so much has sigmoidicity become bound up with the subject of allostery that enzymes showing these kinetics have sometimes been termed allosteric in the absence of any other evidence, though quite different factors may be responsible.)

Despite uncertainty about the mechanism of

Figure 3 The Krebs (or citric acid) cycle, showing the end-product nature of NADH. The dotted arrow indicates control by NADH of the key initial enzyme citrate synthase

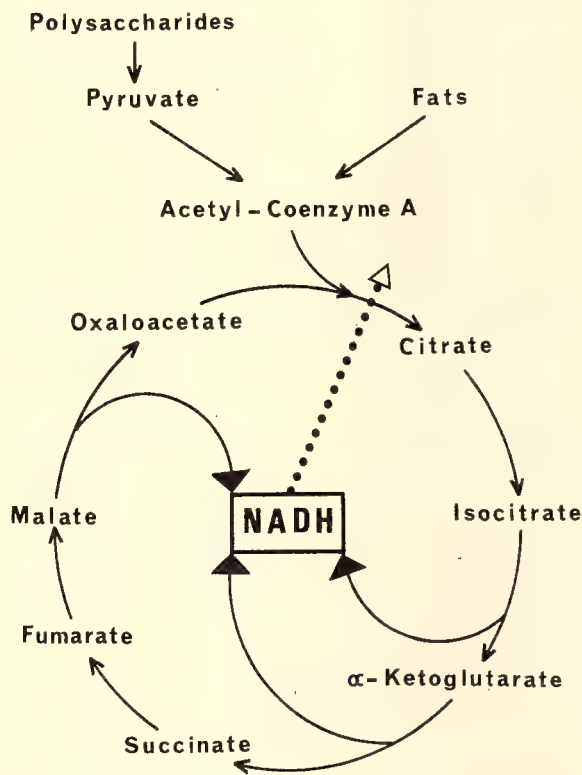
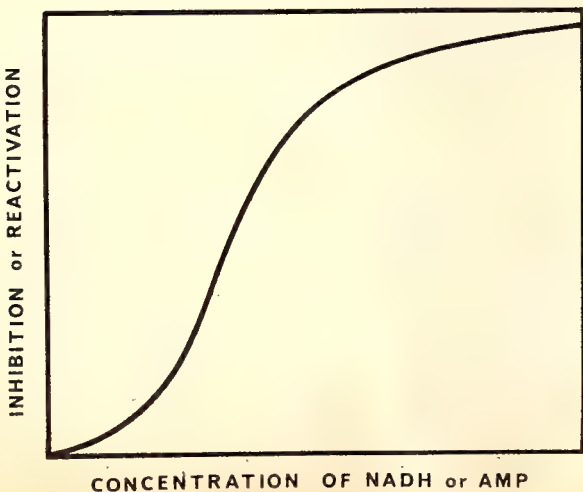


Figure 4 The sigmoid dependence of citrate synthase inhibition or reactivation by NADH or AMP respectively is typical of allosteric enzymes



cooperativity, it would seem that the physiological value of a sigmoid response is that it presents a "threshold". At low concentrations of the effector (lower portion of curve in Figure 4) little effect is produced, but beyond a threshold concentration the curve rises steeply, and small changes in concentration produce sizeable effects on the activity. A sigmoid response may therefore permit a very sensitive control of enzyme activity within a narrow physiological range of effector concentration.

Since there appears to be more than one type of control of citrate synthase, Dr Dorothy Jones and I examined the behaviour of the enzyme from 50 different bacterial species and a variety of higher organisms, and found a pattern of regulatory behaviour that corresponded with the taxonomy of the organisms. Bacteriologists have for years divided bacteria into two large groups—"Gram-positive" and "Gram-negative"—on the basis of their dye-staining properties. Figure 5 shows that only Gram-negative citrate synthases are controlled by NADH; Gram-positive citrate synthases, together with the enzymes from higher organisms, appear to be insensitive to NADH.

Within the Gram-negative group, the enzymes further sub-divide on the basis of their control by AMP. Those able to grow only in the presence of oxygen ("aerobes") are sensitive to the AMP accelerator, but those capable of growing in the presence or absence of oxygen ("facultative anaerobes") are insensitive to AMP. During anaerobic growth, energy is derived not via the Krebs cycle but by a fermentative pathway, and the target enzyme for control by the AMP accelerator probably lies in this pathway. Furthermore, during anaerobic growth, the Krebs cycle operates only as far as α -ketoglutarate, this being an important compound for biosynthesis. Under such circumstances it is α -ketoglutarate, rather than NADH, which is the end-product and, significantly, we have found that α -ketoglutarate acts as a regulator only of those citrate synthases from Gram-negative bacteria capable of anaerobic growth.

The similarity between Gram-positive bacteria and higher organisms may have evolutionary significance. The Gram-positive bacteria are regarded as less primitive than the Gram-negative ones and may even be the evolutionary precursors of mitochondria—structures which, in higher cells, are responsible for Krebs cycle activity.

Differences in the mode of regulation have been observed with other enzymes and may underlie the differences between organisms. The basic unity of metabolism appears to have superimposed upon it a diversity of control.

In general, allosteric enzymes appear to be polymeric—that is, made up of a number of sub-units. Indeed, this sub-unit structure is a cornerstone of the Monod model, which accounts for allosteric behaviour in terms of the symmetry and interplay between sub-units. With this in mind, Patricia Dunmore and I have examined the molecular sizes of representative enzymes from the three types of citrate synthase shown in Figure 5. Significantly, those enzymes showing allosteric control by NADH are large molecules of molecular weight around 250 000. By contrast, those citrate syn-

Self-control for enzymes

Figure 5 Pattern of regulatory behaviour of citrate synthases from various organisms. There is clear correlation between regulation and the taxonomic classification of the organisms

NADH control		No NADH control
Gram-negative bacteria		Gram-positive bacteria and higher organisms from moulds to man
AMP control	No AMP control	
Strict aerobes	Facultative anaerobes	

thases devoid of allosteric properties are much smaller molecules of a third to a quarter this molecular weight. The large molecules are almost certainly polymeric, and we are now studying whether they are aggregate forms of the smaller enzyme or mixed complexes of the smaller enzyme with a regulatory sub-unit.

As I said earlier, changes in conformation are believed to underlie the control of enzyme activity, though experimental evidence for such changes has been gained only indirectly by various chemical and physical techniques. Our good fortune at achieving the purification of citrate synthase from *Acinetobacter lwoffii* (a Gram-negative aerobic bacterium) tempted us to examine it in the electron microscope, in the hope that the much postulated allosteric conformational change might be sufficiently gross to be visible by this technique (see "Monitor", vol.43, p.366).

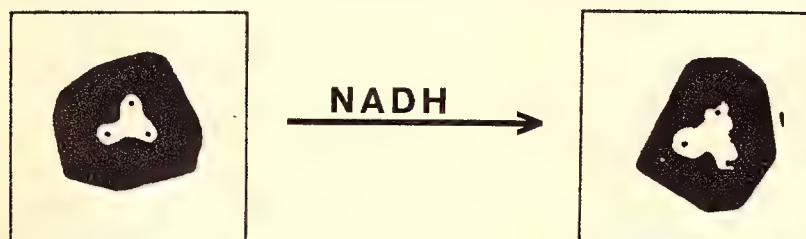
Dr Arthur Rowe and I examined the enzyme by both negative-contrast and metal-shadowing, and looked at the enzyme alone, enzyme+NADH, and enzyme+NADH+AMP. Measurement of the diameters of the enzyme molecules revealed a change from 100 angstroms (enzyme alone) to about 120 angstroms in the presence of NADH. Thus NADH causes the enzyme to exist in a "swollen" condition, the sub-units having moved

apart from one another. It is in this swollen conformation that the enzyme is inactive. However, in the presence of both NADH and AMP (the latter present at a concentration sufficient to overcome the NADH inhibition completely, measurements showed that the enzyme reverts to its former, more compact, conformation in which it is fully active. Our electron micrographs showed some molecules with 3-fold symmetry: by superimposing these in groups of eight we obtained pictures like those in Figure 6. Here, the effect of NADH in causing the sub-units to move apart is clearly apparent.

The electron microscopy results are backed up by ultracentrifugation experiments in which we studied the sedimentation of the enzyme with and without NADH and AMP. NADH caused a retardation of sedimentation rate consistent with the swelling of the molecule, while AMP overcame this retardation.

It appears that in the case of citrate synthase, allosteric effectors do indeed control enzyme activity via conformational changes in the enzyme molecule. The exploration of the finer detail of the process in this, and in other, enzyme systems will lead, ultimately, to a better understanding both of how enzymes work and how their built-in control mechanisms operate.

Figure 6 Superimposition (in groups of eight) of electron micrographs of individual molecules of citrate synthase, negatively contrasted in ammonium molybdate, with and without NADH. The dots mark the estimated centres of the sub-units which clearly move apart in the presence of NADH. Magnification X 1 000 000



Tantalizer No. 116 The Munchausen Tournament

Perhaps the most improbable chess tournament of all time was played at Munchausen in 1876. There were 26 entrants, and the name of each began with a different letter of the alphabet. All played all, scoring 2 for a win, 1 for a draw and 0 for a loss. No one totalled an odd number of points and there were no ties in the final order.

Astonishing to relate, they finished up in exact alphabetical order.

What was the result of the match between N and M?

Martin Hollis

For solution to Tantalizer No. 115 see page 548

Atmosphere on the move

Exciting possibilities for a global surveillance of the atmosphere in the late 1970's were reported during a recent meeting at the Royal Society, when the Royal Meteorological Society joined forces with the American and Canadian Meteorological Societies. Crucial experiments then should allow meteorologists to determine the potential value of extended range forecasting by numerical methods — techniques which were used recently to simulate the atmospheric circulation of Mars

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The Earth is a rotating planet, its surface characteristics vary considerably, and it is subjected to differential heating from the Sun. Not surprisingly, therefore, the circulation of its atmosphere is complicated. Indeed, in many parts of the world an observer aware of only his local weather might be excused for regarding the atmosphere's behaviour as totally chaotic. Nevertheless, when examined globally it becomes apparent that all is not chaos; there is, in fact, a high degree of organization and continuity in the circulation. George Hadley, in 1735, was the first person to recognize this organization. He suggested that the trade winds were air currents which moved towards the equator in response to thermally induced ascent in equatorial regions and acquired their easterly component as a result of the rotation of the Earth. This part of his diagnosis, although incomplete, remains essentially correct today.

If the atmosphere could be made to remain stationary, the balance struck between the incoming radiation from the Sun and the outgoing long wave radiation lost to space would cause a larger poleward temperature gradient than actually obtains. The tropics would be hotter and the polar regions colder. Fortunately for us, however, the atmosphere can move and its general circulation serves to mix the atmosphere on a global scale. Because of this circulation, which is subject to dissipation by friction, the poleward temperature gradient settles down to a value rather less than would be required by a purely radiative balance. Thus the circulation is continually transporting heat towards the poles, to replenish the radiative deficit in high latitudes and angular momentum polewards to offset the dissipation of the mid-latitude westerlies by friction. The broad details of the circulation that fulfils these functions are now well established.

The depressions encountered in middle latitudes, which were once regarded as merely giant mechanical eddies or "macro-turbulence", are now seen to play a different and more vital role. They are unstable disturbances which draw on the available potential energy created by differential heating and convert this into kinetic energy, so making up for frictional losses. In low latitudes an important part of the poleward transports is effected by the meridional motions of a mean toroidal cell, with rising air in the tropics supplying a poleward current aloft. (This is the Hadley cell, which also explains the low level trade winds.) However, evidence was put forward at the conference to suggest the existence of large scale eddies in the tropics having a greater degree of organization than previously supposed, so even in these latitudes the eddies probably make a significant contribution. Considerable progress has been made from analyses of satellite

as well as conventional data towards establishing the details of the complicated energy conversions and transports on a quantitative basis.

Precise modelling of the global atmosphere in the laboratory is clearly impossible. Nevertheless, models embodying the essential ingredients of rotation and differential heating have been used extensively to study the fundamental properties of the flow of fluids under such conditions and have provided valuable insight. Speaking at the conference, Dr R. Hide of the Meteorological Office reviewed the scope and application of such techniques and described some new results obtained when internal heating by electrical means was applied within the body of the fluid, as distinct from purely externally applied heating. This can be regarded as a crude simulation of the internal heating of the atmosphere provided by the release of latent heat of condensation in cloud systems. The motions in the laboratory fluid models include large amplitude baroclinic waves superposed on a zonal flow about the axis of rotation. They have a striking resemblance to the large scale planetary waves which are a feature of the atmospheric circulation.

In the past, the observation of the flow in such laboratory work has been confined almost entirely to the upper surface of the fluid, using suitable tracers, whereas ideally one would like to study the three-dimensional structure and flow. However, under the direction of Professor R. L. Pfeffer at Florida State University an ambitious attempt to overcome this limitation is now under way. Professor Pfeffer and his colleagues have constructed a laboratory model using 100 probes to monitor events throughout the interior of the fluid. They have largely overcome the problem of introducing the probes with a minimum disturbance to the flow under study—so much so that it is believed the number of probes can be increased to perhaps 1000. This certainly gives a new stimulus to laboratory modelling of the atmosphere.

An alternative, and extremely powerful, line of attack is to set up the mathematical equations governing the motion and heat balance of the atmosphere. By integrating the system forward in time from a known initial state, it should be possible to simulate numerically the way in which the motion and structure of the atmosphere will evolve. The classic equations of hydrodynamics and thermodynamics provide the basic framework for such a model but one must also include a satisfactory representation of many complex physical effects—especially those which concern the internal and external sources and sinks of energy for the system.

For many of these, no adequate theory yet exists and we have to lean heavily on empiricism. This is



Atmosphere on the move

particularly true of the important exchanges of heat, moisture and momentum between the atmosphere and the Earth's surface. The system of equations is highly non-linear and many subtle feed-back mechanisms operate. Typically some 200 000 variables may be employed to specify the structure of the global atmosphere at any instant, and there are severe mathematical difficulties in maintaining computational stability and minimizing truncation errors during the integration forward in time. This kind of work poses a computational problem among the largest currently mounted on computers.

One of the most impressive experiments with such a numerical model, carried out in the Geophysical Fluid Dynamics Laboratory of ESSA under the direction of Professor J. Smagorinsky, has been the successful stimulation of what we may call the "dynamical climatology" of the atmosphere. Starting from an initial state of uniform temperature and with no wind anywhere, the model was integrated for 300 simulated days. Not only did a temperature structure and circulation develop in the model in close accord with those of the real atmosphere, but elaborate diagnosis has also established that the model achieves the necessary energy conversions and transports in broadly the same manner as does the atmosphere.

Many other kinds of experiment can be conducted with such a model. Professor Y. Mintz of California University even described an attempt to use a numerical model to predict the general circulation of the atmosphere of Mars. He assumed an atmosphere comprising two-thirds carbon dioxide and one-third nitrogen and having a pressure at the surface about 1/130 that of the Earth's atmosphere. In the winter hemisphere the predicted circulation had strong west winds and disturbances analogous to depressions on Earth, but in many other respects was substantially different from the circulation of our atmosphere. Ice caps (of solid CO₂) appeared in the model, their formation depending more on the limited ability of the Martian atmosphere to transport heat into the polar regions than on the local radiative conditions of those regions.

Numerical prediction

Returning to our own atmosphere, relatively simple numerical models have achieved useful success in predicting the future behaviour for a day or two of systems already existing or clearly implicit in the initial conditions. Numerical prediction as an aid to short period weather forecasting has been an operational routine in several meteorological services for some years. Naturally, this raises the question of whether the advanced numerical models now in use for research have potential value for extended range forecasting if we use them to predict forward.

For this purpose it is not sufficient for the model to have demonstrated a realistic capability of, say, predicting plausible sequences of depressions in temperate latitudes. The demands on the verisimilitude of the model are now much more severe. To exploit such a model in making extended forecasts, other than in the vaguest terms, the depressions

must be predicted to form in the right places, at the right time and with the correct structure and vigour. For how far ahead can we hope to achieve this?

Meteorologists are not yet agreed as to the ultimate limit of predictability of the atmosphere—which we might define as the limit attainable with a perfectly faithful model supplied with complete and accurate global data. Weather systems range in scale from the planetary waves, through the depressions and anticyclones, down to the individual cumulus clouds and even smaller turbulent eddies. It is an inescapable property of the complete system that all scales interact with each other, and the pessimistic view is that we cannot hope to forecast very far ahead the weather systems of scale, say, 1000 km upwards even if we were prepared to treat explicitly all the smaller scales as well. (The latter would, in any case, pose observational and computing requirements of staggering proportions.)

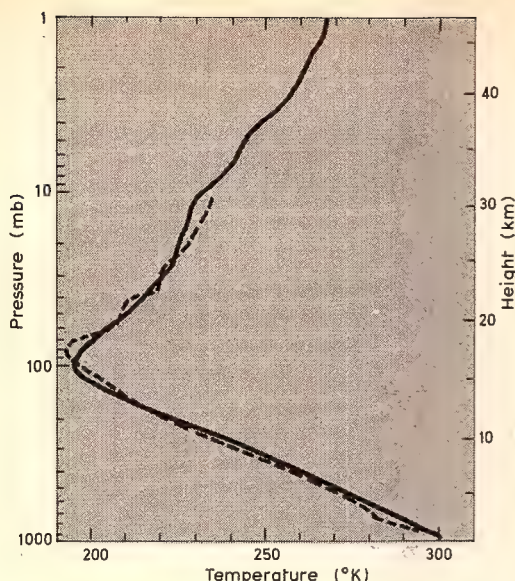
On the other hand, the energy spectrum of atmospheric systems has not yet been adequately established. It may be that if there is little energy in the scales somewhat smaller than that of the depression—as many meteorologists believe—it will not be necessary to deal with the smaller systems individually. Some form of empirical representation of their cumulative effect on the larger scales may thus suffice. (The predictability of the atmosphere was discussed more fully by Professor E. N. Lorenz in a recent article in *New Scientist*, vol. 42, p.290.)

Improving accuracy

Whatever the ultimate limits of predictability may be, there is little doubt that the latest numerical models offer a real hope of improving the accuracy of short period forecasts and perhaps of extending their range so that predictions for a week or so ahead will be comparable in accuracy to those now made for the next day. However, appraisal of the power of these methods is now seriously hampered by inadequate data. Some 500 or so radiosonde/wind soundings record the three-dimensional flow and temperature structure of the atmosphere over the northern hemisphere at least once daily. Yet the distribution of these data is highly irregular and there are vast ocean areas where observations are particularly sparse. The situation in the southern hemisphere is, of course, much worse. The state of the atmosphere is thus not observed sufficiently well either to provide the initial data from which the numerical models can proceed or to allow proper verification of forecasts.

Mainly because of these shortcomings, and in view of the high promise of the numerical models, the International Council of Scientific Unions and the World Meteorological Organization have established the machinery of an ambitious Global Atmospheric Research Programme (GARP). Aside from various sub-programmes for research into particular aspects of the problem, the main effort is being directed towards setting up for a limited period, probably in the late 1970s, a truly global surveillance of the Earth's atmosphere! Only in this way can we advance significantly our understanding of the global circulation and carry out the necessary crucial experiments to assess the

An example of remote sensing of the vertical temperature of the atmosphere from the *Nimbus III* satellite when over the West Indies on 14 April 1969. The dashed curve shows for comparison a nearby sounding made by conventional methods (from Dr D. G. James, Meteorological Office and colleagues at the National Environmental Satellite Centre)



potential value of numerical models for extended range forecasting.

The minimum requirements are for regular global observations of wind, temperature and water vapour, at several levels up to 30km, and at lateral intervals of 400km. To achieve this by conventional methods of observation is clearly impracticable, but there are hopes that it will be possible to go a long way towards meeting it if the opportunities afforded by the rapid advances in satellite meteorology are exploited to supplement conventional methods. The proposals provide for the maintenance of 1000 or so constant-level balloons in the atmosphere as tracers of the air motion and for the tracking of the balloons from low orbiting satellites as a means of determining

the wind. The balloons would also carry temperature sensors. Also, geostationary satellites would be used for global monitoring of the cloud systems (see cover picture) and for other purposes.

In this connection, by far the most exciting prospect, revealed at the conference by Dr D. G. James of the Meteorological Office, springs from the immediate success achieved by an infrared spectrometer mounted on the *Nimbus III* satellite launched on 14 April of this year. The instrument, which is a prototype for the future remote sensing of the atmosphere, measures radiances within seven intervals in the 15 micron band of carbon dioxide and in one interval in the 11.1 micron "window". The radiances implicitly contain information about the vertical temperature structure of the atmosphere but the inversion of the radiances to obtain those temperatures is by no means straightforward.

Nevertheless, a method has been devised and more sophisticated techniques are being developed. The impressive progress can be seen from the example (see Figure) of a vertical temperature sounding deduced from the remotely sensed data obtained when the satellite was over the Jamaica area soon after launch. The figure includes for comparison the structure measured nearby by a conventional radiosonde instrument released from the ground. Admittedly there are outstanding difficulties in interpreting the data, especially in the presence of clouds, but the potential of the method for a global observation system is clearly considerable.

Does design pay?

This week designers and businessmen are meeting in London at the sixth congress of the International Council of Societies of Industrial Design, to discuss the theme of design, society and the future. Although far too little attention is paid to the benefits of good design in Britain, the proposed establishment of a national design council to cover the whole range of industry, with a greater engineering slant, should ensure that design is valued more highly

Olga Illner-Paine

is editor of the science, industry, and agriculture unit, BBC External Services

Ask a dozen people what they mean by design and you will get a dozen different answers. Some think of it simply in terms of patterns, while others think of pottery and basket-weaving. Others envisage a blueprint for the future, and yet others think of styling for a new car. The wide scope of design is part of the reason for its fascination, but can be an embarrassment to the profession. What the practical designer needs most today is a decisive image. Yet, surprisingly, out of some 12 papers given during this week's congress by speakers from Britain, US, Canada, France, Italy, Sweden, and the Soviet Union, only one is really devoted to practical consideration on how the designer must equip or re-equip himself to fulfil his role in a rapidly changing technological world.

Where does the designer stand today? Broadly speaking, he is reasonably well established in the field of consumer goods; it is now understood that, whether you make wallpapers or tin-openers, it pays to employ a designer. But outside the consumer sector the picture is patchy. To some extent this may be due to lack of communication. Consumer goods are widely displayed and whatever thoughts

they may inspire are widely shared. In comparison, a machine, however ingenious, makes a relatively small impact, except on immediate competitors. They will get the message that design pays only too quickly but there will be no echo in a wider industrial field. And here lies the great potential value of the award scheme for capital goods introduced by Britain's Council of Industrial Design (CoID) in 1967; it helps to publicise the theme that design *does* pay.

A textbook example is the 9 RJ-36 circular knitting machine, a CoID award winner, designed and made by Wildt Mellor Bromley Ltd of Leicester, a member of the Bentley Engineering group. The machine caused a sensation when it was launched on the international scene during the Basle textile machinery exhibition in 1967. Compared with earlier models it provided a 45 per cent increase in output for an increase in price of only 25 per cent. To a fashion-conscious trade it offered an extra large pattern area and a pattern-changing system simple enough to justify even short runs. Not surprisingly, the 9 RJ-36 netted orders worth £3 million at Basle and the firm's entire production is now sold until



The 9RJ-36 knitting machine made by Wildt Mellor Bromley Ltd, seen here installed in a modern knitting plant, won a design award from the Council of Industrial Design, and gained more than £3 million worth of orders in 10 days when launched at the Basle Textile Machinery exhibition in 1967. The design has ensured that the machine can be run continuously with the minimum of maintenance and needle breakage (Photo: CoID)

the middle of 1971. It is worth noting that 220 people—that is 10 per cent of the firm's labour force—is employed on design and research.

Another classic example of how thoughtful design can change a company's fortunes is the "Mono-box" overhead travelling crane, made by J. H. Carruthers and Company Ltd, of College Milton, Kilbride. This crane, which replaced the old range of double girder cranes, is the winner of a recent design award. It was the first overhead travelling crane to utilize the strength and torsional resistance of a light welded-box steel beam from which machinery, cab and load are cantilevered. The new design has greatly reduced manufacturing costs. Typically, engineering drawing time for a crane in the range has gone down by some 350 man-hours to 18; fabrication of the structure now takes a third of the previous time and there is a reduction of a similar order in assembly time. Overall, the new crane has changed the prospects of a company which had found itself losing its place in this highly specialized market. The firm has already built 500 Monobox cranes, and has sold licences to Holland, France, US, South Africa, Australia and Japan.

In these cases commercial success followed an advance in design, but this does not happen automatically. It would be interesting to know, for instance, what is the effect of a design award on the performance and general attitude to design on companies in a related or wider field. Will they be goaded into taking a more active part in matters of design? (At present 30 per cent of manufacturers refuse invitations to exhibit their products in the Design Centre.) Or will they be encouraged to improve their own designs? To take an example—will Chubb's cash dispenser (Chubb & Sons Lock and Safe Company Ltd), which earned the company this year's Duke of Edinburgh's prize for elegant design, stimulate other manufacturers to improve the look of their batteries of garish vending machines? What is the real value of an award to the company concerned? Is it lasting or does it quickly evaporate? All these questions are as yet unanswered.

Already, however, one important case has come to light where one wonders just what the award has achieved. This concerns an ingenious design known as the Thompson-Watts map plotter, which is

based on an invention by Professor E. H. Thompson, who holds the chair of photogrammetry in the department of civil engineering at University College, London. When the makers, Hilger & Watts Ltd, were taken over by the Rank Organization, production of the plotter ceased. Professor Thompson, who meanwhile has devised a potentially much cheaper prototype of a similar tool, is left to look for an interested manufacturer. One wonders whether the outcome would have been different if the CoID had had machinery at its disposal for follow-up studies of award-winning designs. As it happens, the council is about to be reorganized and is expected, before long, to become the National Design Council, with far greater emphasis on engineering design. Within the framework of such an enlarged institution, it should be possible to make certain that top designs, once recognized as such, do not end up in some pigeonhole. One would also like to see such an enlarged body spread its influence more broadly, particularly to smaller firms.

A pilot project with just that aim was carried out a few months ago and produced reasonably hopeful results. Backed by the Board of Trade and concentrated in Bristol and Glasgow, the project attempted to sell the design consultancy idea by providing 50 per cent grants for schemes costing from £250-£10 000. The facilities were utilized by 250 companies one-third of whom employed consultants and designers for the first time. Originally it was hoped that the scheme would eventually be extended to cover the whole country but, so far, no more has been heard. This is surely a field where a national design council could operate with great effect.

Another field at which a reconstituted council, with its greater emphasis on engineering design, will have to look very closely, is the training of designers. On the one hand, there are engineers who want no truck with design, and who proudly claim that they can get along very well without all this design nonsense. On the other hand, there are many designers who have not yet understood that they must come to terms with engineering, with cybernetics, systems development, behavioural science, and management. They show no inclination to acquire management knowledge—which they certainly need if they are to move from the fringe, where so many are at present, to the heart of things where they can take a decisive influence on the company's affairs. Dr Arthur Earle, principal of the London Graduate School of Business Studies, and one of the principal speakers at the congress, even holds that designers would do well to take a master's degree at a good business school.

There is also the problem of keeping the design approach fresh. With the present pace of technological change, a designer quickly finds himself out of date. To remain on top of his profession he should be constantly in and out of seminars and refresher courses. At present there is too little opportunity for this and a national council of design could be legitimately expected to take a lead in expanding such facilities. This would allow the designer to attend to what should be considered one of his first priorities—namely to constantly redesign himself.

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Benevolent capitalists

Business is booming at the Messerschmitt-Bölkow-Blohm group near Munich, a firm that combines ingenious technical skills with unconventional management. Now there is talk of inducing refugees from the British aircraft industry to work there

David Marks

is the central European correspondent of *New Scientist*

In the course of the last year or so, the West German aircraft industry has undergone considerable streamlining. A series of mergers has reduced the jumble of small specialized family firms, many with highly evocative wartime names like Heinkel, Junkers, and Focke-Wulf, to three major units. These are the half-German—half-Dutch VFW-Fokker group; the Dornier Company, which is the only surviving independent family concern; and the Messerschmitt-Bölkow-Blohm group.

There is little doubt that the Messerschmitt-Bölkow-Blohm group is the one with the greatest potential. The group has been built up around the Bölkow company, which started life as a small engineering office engaged on the automation of rubble-clearing and building equipment in the grey days just after the war. In 1956 this blossomed into Bölkow Developments, concerned with a wide range of research and development projects, and later with the influx of first American (Boeing) and then French (Nord Aviation) money became a limited company in 1965.

During this period, the firm built up an impressive reputation for unorthodox, original ideas and ingenious solutions to technical problems, and much of their work was done on government

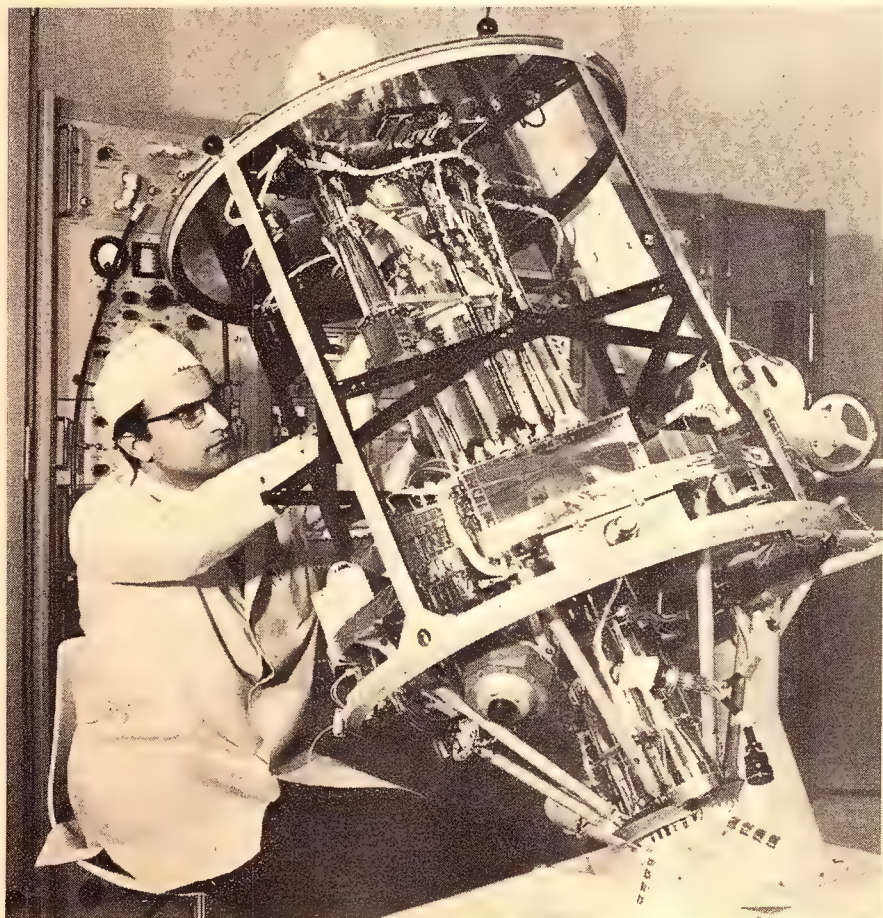
contract. They repeatedly managed to interest Bonn in their ideas and get government money to develop them. In this way a very wide spectrum of experience was acquired and the firm became comparatively prosperous merely by selling paper. They were also helped by a number of rich Germans, who, sensing that here was one of the main hopes for the new Germany, risked large sums of money, virtually with no strings attached. The Boeing Company of Seattle became intrigued by the number of times the name Bölkow was cropping up, and sent over observers in the '60s. At first they were a little disappointed by what they saw in the way of buildings and equipment, but they too sensed the potential and became major shareholders when the limited company was formed.

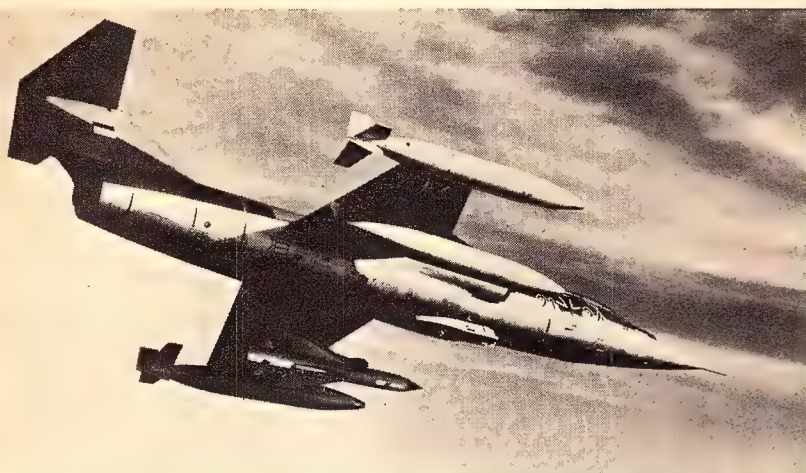
In October 1968 the merger with the Messerschmitt group was finalized, and in May this year a further merger brought in the Hamburger Flugzeugbau GmbH, to create the present Messerschmitt Bölkow-Blohm GmbH. This last merger was something of a tactical triumph, as an offer had already been made by the VFW-Fokker group, which, had it been accepted, would have resulted in a north-south division of the German aircraft industry. In Germany regional loyalties still tend to play an important, if unofficial, part when contracts are being awarded—a fact which almost certainly helped the progress of the south German Bölkow set-up when Franz-Josef Strauss was Defence Minister. Now, by capturing the Hamburg firm, the MBB group have not only added a considerable potential for production to their extensive R&D facilities, but have also given themselves a major foothold in the north and thereby a much more universal appeal.

At the group's headquarters in Ottobrunn, near Munich, the visitor is struck by an atmosphere of satisfaction with what has been achieved and confidence for the future. A powerful respect for American methods is very marked (heavily drawn on in pushing through the mergers), and "systems" is the watchword. Even the firm's external PR magazine, previously called *Report*, has now been rechristened *System*.

It is in the context of European and North Atlantic space projects that the group is making its biggest impact at the moment. Undoubtedly the biggest disappointment so far has been the double failure of the third stage of the ELDO launcher, for which MBB and Entwicklungsring Nord, Bremen, are jointly responsible. However, they are taking things philosophically in Ottobrunn. They point out that the third stage is by far the most complex, and, hinting darkly at some vast unknown total of early American failures, they add that no successful rocket system has been completely free of initial setbacks. They hope to get some useful leads on the cause of the failure from the telemetry records and,

Azur, due to be launched in November, is the first all-German research satellite.





The new long-range missile Kormoran, mounted under the left wing of a Starfighter

pending the results of this investigation, preparations are going ahead as planned for the next ELDO launching (F 9), the last scheduled to take place from Woomera before the move to the French Guiana base.

On the positive side, there is the highly successful ESRO satellite *Heos-I*, which was launched last December and has since been functioning perfectly. This has now been followed by the contract for its successor *Heos-II*, to be put up at the end of 1971. The first all-German research satellite *Azur*, due to be launched by an American Scout rocket in November this year, has grown out of the early studies of the pioneering Bölkow satellite group, and the systems management, testing and integration of the project have all been carried out from Ottobrunn. Work is also well advanced on the combined German-French communications satellite *Symphonie*, which is to be placed in stationary orbit by the ELDO launcher probably in 1973. Here MBB are responsible for the integration of the project, and for the attitude control and measurement, the development and supply of the sub systems, and the supply of the apogee engines.

Detailed studies have been completed for two German-American projects which were approved by the two nations in June this year—the solar probe *Helios* due to pass a short distance from the Sun sometime in 1974 and an aeronomic satellite planned as a successor to *Azur*. Looking further ahead, a project analysis has just been completed and submitted for an ESRO Mercury probe suggesting 1975 as the possible launching date. Further projects being developed at present include the German-French DIAL technological and scientific satellite, the SPAZ scientific payload cones, an automatic orbiting operations system for satellites (AOOSY), and numerous others.

The MBB group is not only concerned with outer space, however. It began to make small private planes as soon as aircraft production was again permitted in Germany and was later engaged in the development of the experimental VTOL aircraft VJ 101 X-1 and X-2, the world's first high-performance VTOL models with supersonic speed in level flight and reheat thrust in the transition phase. Another successful Bölkow development is the rigid rotor, two-engined BO 105 helicopter. This is now likely to be produced under licence by Boeing-Vertol and should help to spread the firm's name at

the international level. The MBB group is now a major partner in the recently formed Panavia Aircraft GmbH, the combined British, German and Italian company for the development and construction of a new European combat aircraft as the successor to the Starfighter and the Fiat G 91, and also has a 40 per cent share in the project for a European air-bus.

Ever since the rearmament of Germany, missile and weapon development has been one of the most profitable branches of the firm's activity. Bölkow were very quickly in the field with the wire-controlled COBRA anti-tank missile, and over 100 000 of these have been supplied both to the Bundeswehr and foreign armies. Numerous manufacturing licences have been granted, and the missile is still selling well. The second generation anti-tank weapons MILAN and HOT are at present in an advanced pre-production phase, and the successful testing of the ROLAND series for defence against low-flying aircraft was recently celebrated. KORMORAN, a long-range air-to-ship missile which flies low over the sea beneath radar cover and seeks out its target while the launching aircraft escapes to safety, was recently unveiled at the Paris Air Show. In spite of the fact that much of this weapon development is carried out in close co-operation with Nord Aviation, the success of the MBB Defence Technology Division has induced Moscow Radio to brand Ottobrunn as a "second Peenemünde".

Closer to everyday life, the group is also very active in the field of transport systems, and has developed new fully welded light aluminium coaches for the underground railway now being built in Munich. It has also just been awarded a 6.8 million mark government contract for a study, to be completed by the end of 1971, which should determine whether and to what extent traffic and transport conditions could be improved by a completely new style of rail system, not necessarily bearing any resemblance to the existing railways. Above all, this high-performance, high-speed rail system should reduce the overloading of the long distance roads. The ideal is a system on which trains can travel in both directions at speeds of between 300 and 400 km/h, carrying fully loaded giant lorries and trailers packed one above the other, rather like the present long-distance trains for the transport of private vehicles.

These are only the star projects of this very prolific group, which also has interests in civil aircraft, marine technology, cybernetics, and many more. The present level of success can, of course, be maintained only so long as contracts continue to pour in, but MBB feel that they have now become enough of an "institution" and a symbol of the future for there to be a major outcry if they were to be cut back. There is certainly no shortage of contracts at the moment, and the main problem is going to be to find enough engineers of sufficient quality to carry them all out. The group's giant neighbour in Munich, Siemens, is in a position to buy up and fully occupy the entire output of the Munich Technical University.

To combat this, MBB emphasize their wide range of highly interesting projects firmly aimed at

Benevolent capitalists

the future, and strive to provide excellent working conditions. Inducements include high rates of pay; pleasant surroundings; a sliding working day where, within certain limits, the employees are free to start and stop work when they like (*New Scientist*, vol. 43, p 367); a structure where there is every prospect of getting to the top by 40; and an atmosphere where even the most crazy-sounding ideas will be listened to sympathetically in the tradition of the original Bölkow company. This policy of benevolent capitalism seems to be bearing fruit and the workers in Ottobrunn make a very contented impression. Because of the pressure of contracts, the employees (average age only 37) have willingly agreed to a regular working week some three hours longer than the union normal—paid, of course, at slightly above union overtime rates.

A tie-up with Siemens is on the verge of completion, and will probably lead to a considerable increase in the basic capital. As a result, Siemens will gain important new outlets for their great electronic potential in fields such as space and

weaponry, branches where they have not been particularly active up to now. MBB, for their part, will be able to lay claim to the vast Siemens resources, both when applying for contracts and when carrying them out. However, there is another, less trumpeted advantage for them from this projected link. A trickle of engineers from Siemens to Ottobrunn has already begun, and once the two firms are part of the same organization, it will become far simpler for them to transfer to divisions which excite their interest without having to suffer any personal disadvantages. In Ottobrunn, they are confident this will be a one-way traffic.

In spite of all these efforts, there is still likely to be a major shortage of highly qualified personnel for many years to come. There is even talk of trying to induce refugees from the British aircraft industry to spend periods of 10 years or so working in Germany. It is not inconceivable that, if Britain continues to cut down on long-term development projects, we may soon find ourselves up in arms about a new "brain drain"—this time to the continent of Europe.

The crippling cost of power

Industry in Britain has to pay too much for its electricity. The high price puts established industries at a disadvantage compared with their overseas competitors and discourages new ones. It is time that industry paid less and the householder more

Dr Georg Tugendhat

a co-founder of Manchester Oil Refinery Ltd, Petrochemicals Ltd, and Petrocarbon Ltd, is now an industrial consultant on oil, chemicals and other problems

It is about time that we paid greater attention to the future of electricity prices in Britain than to the structure of the industry. The future relations between the new Electricity Authority, the Central Electricity Generating Board, and the area boards are a matter of great administrative importance, but unless there is a clear understanding that cheaper electricity tariffs must be the prime objective of the new authority, the outlook for British industry will be grim.

In short, with a minimum tariff of 1d/kWh (or exceptionally 0.9d) we simply cannot compete against industries abroad which pay as little as 0.25d—on average 0.5-0.8d. US industry pays 0.5d/kWh, and in a number of places a good deal less. The need to grant an exceptional rate has been recognized in the case of the British aluminium smelters, but there are other segments of industry in which the cost of electricity plays just as decisive a role. In the case of the old-established industries, making chlorine, caustic soda, calcium carbide and phosphorus, energy costs can account for more than half of the manufacturing costs.

More important are the new industries which are not being developed—and cannot be developed—until electricity tariffs take account of their requirements. This development will have a decisive influence upon our balance of payments. In the newer industries, research is often held up by the knowledge that if such research is successful electricity costs will kill the business. Some time ago ICI announced that it would extend the production of silicones, but could not embark upon

manufacture of the raw material because of the high cost of electricity. Imports would, therefore, have to be continued (chiefly from the USA). Another, perhaps even more important, field is the production of chemicals in plasma, where coal could be used as raw material, thus eventually replacing imported petroleum. Laboratory research has reduced electricity power requirements from 3-6 kWh/lb to 1 kWh/lb—which, because of the enormous operational losses, is still far above the theoretical figure. It is clear that with the cost of electricity at 1d/lb the chances of arc, glow discharge, or corona chemistry being developed to the commercial stage in this country are much smaller than in other countries, where electricity costs 0.5d/kWh or below.

Take the case of the steel industry, an industry in revolution. The new, big, basic-oxygen steel-making furnaces will have a capacity of up to 300 tons per hour of steel. To become an integral part of a production train the continuous casting unit must at least match the furnace. Oxygen usage per ton of steel is rising fast and there is a very promising development towards achieving a really "continuous" continuous-processing technique, as US Steel calls it. In the development of smaller steel plants the role of the electric arc furnace is becoming increasingly important and the most recent step is the emergence of the ultra-high-power concept. In UHP, power density, expressed in kW per square metre of molten bath, is approximately twice those of potential furnaces.

Continuous casting has given vacuum degassing

a new importance. Iron and steel-making techniques are also making steady progress towards manufacturing better steels—new high tensile, ultra high tensile, and stainless steels, stronger and more ductile than the previous ones. BISRA—the inter-group laboratories of the British Steel Corporation—and British companies are playing the leading role in these developments. All of these processes will use more and more electricity.

Finally, there is the move towards direct reduction and the production of steel from pelletized iron ore. It is estimated that the oxygen consumption in direct reduction would equal the present consumption in all other steelmaking processes. The Electricity Council for England and Wales, advertising the advantages of the electric induction furnace, gives electricity costs of 1.12d/kW—i.e. the maximum demand tariff rate. At this price, electricity costs are just about equal to all operational expenses, excepting the metal charge. Assuming that operating expenses in the UK equal those within the EEC and Scandinavia, a company paying half the rate will have an insurmountable advantage over its British competitors. Tin and copper industries are also starting to use oxygen, and direct oxidation processes are being developed rapidly in the chemical industry.

Britain's economic future will very much depend on how far we can develop these new electro-chemical and electro-metallurgical processes. In an address to the 1967 meeting of AICHEM, Professor K. Winnacker, then the chairman of Hoechst, estimated that between 1952 and 1967 the turnover of chemical products in the world had increased threefold. He estimated the share of energy costs in the gross value of chemicals at 12 per cent, and emphasized the danger to the whole economy in under-rating the role played by electricity in modern processes, particularly in chemical reactions. His successor, Dr Sammet, pointed out on another occasion that energy costs in Germany are double those in the US at present. He and some of his colleagues from other concerns said they would have to move industry into other countries where lower prices prevailed. Hoechst has already done so in the case of phosphorus, where new products have been moved to the Netherlands.

Professor Winnacker did not mention in detail another field of industrial activity in which electricity costs are decisive—the manufacture of industrial gases, oxygen, nitrogen and the rare gases, helium, argon and krypton. The production of one ton of oxygen from air by liquefaction requires 300-400 kWh (modified Linde-Frankl cycle). If it is made by another process as compressed oxygen with an accompanying 2 tons of liquid nitrogen as byproduct, the electricity requirements rise to 500 kWh. The production of rare gases also demands substantial quantities of power; the demand rises considerably and by several factors in the case of helium, an increasingly important commercial chemical.

Electricity consumption in the plastics industry is also very heavy—a fact that is often overlooked. Production of one ton of high-density polythene requires pressures up to 2 500 atmospheres, which in turn needs 1800 kWh per ton.

Another very important field is the enrichment of uranium, where the cost of electricity contributes almost half the cost of U-235. The cost of electricity, therefore, greatly affects our competitive position in the supply of enriched uranium to the world. To some extent it also affects the export of nuclear power plant, as a customer will often consider it an advantage to place the contract for the enriched fuel with the same country from which he buys the reactor. In order to supply the replacement fuel for 1 000 MW of enriched uranium reactors (e.g. AGRs or light water reactors), about 30 MW is needed to produce the enriched uranium in diffusion plants; this is in addition to the quantities required to supply the initial fuel charges.

The need to bring down electricity tariffs for certain industrial operations, and indeed for industry generally, has become particularly important for two reasons. During the last few years many industries employing electro-chemical electro-metallurgical, high-pressure chemical, and oxidation processes have moved to the north-west coast of Europe, in an area stretching from Amsterdam to Zeebrugge, and further south. Something like £4000 million has been invested in the manufacture of steel, chlorine, phosphorus, aluminium and petrochemicals. Some British firms have already taken advantage of the favourable conditions prevailing in this area, particularly as they affect energy costs.

Apart from the threat from these industries now situated in the north-west corner of Europe, we have to consider world competitive conditions in the trade generally. Here the picture is confused by the many fiscal advantages which all industrial countries now grant to their exporters and the many advantages given to industries moving into what are called development areas in Britain. But all fiscal and monetary bidding has its limits. In the end the true cost will decide the winner in the competitive game. The country in which industry pays for bulk demand at a rate of 1.01d/kWh (and in very exceptional circumstances 0.8d), will always be at a disadvantage against a country where 0.5d and even less represents the cost of electricity. An indication of the existing state of affairs may be obtained from the tables given in the 18th enquiry of the electricity supply industry by the Organisation for Economic Cooperation and Development (OECD). Of Germany's total estimated consumption for 1969 of 200 000 GWh, 45 000 GWh goes to the electro-chemical and electro-metallurgical industries, 17 000 GWh to the steel industry, and 117 000 GWh to industry altogether. Households consume 36 400 GWh. For France, the figures are: total consumption 135 000 GWh, electro-chemical and electro-metallurgical 17 000 GWh, steel industries 11 000 GWh, total industrial demand 80 000 GWh, domestic 18 000 GWh. In the UK total consumption is put at 227 000 GWh, electro-chemical and electro-metallurgical industries taking 23 000 GWh, steel industries 13 000 GWh, total 90 000 GWh. Domestic demand is 76 000 GWh. In Sweden, Switzerland, and Holland industrial demand for electricity exceeds proportionally the British figures.

We must recognize the tremendous difficulties facing the CEGB, and the Electricity Council, or

whatever authority will take their place, in the matter of tariff policy. The industry has assumed the financial objective of producing a gross profit of about 12 per cent on its book assets. It is by statute compelled to treat all consumers alike, taking into account offtake, night and day consumption, and other factors. Above all, its tariff policy is historically biased to give preference to the domestic consumer. In the UK the ratio between the industrial and domestic tariffs is 0.8 to 1d, but on the Continent it is much higher.

Because the cost of electricity enters into the cost of living index, a change in the ratio would meet violent opposition from domestic consumers, and also raise serious political problems. This problem of restructuring electricity tariffs would still remain with us, though probably in a milder form, if all the out-of-date plants were closed down and the whole system operated on the most up-to-date generating stations only, without any restrictions on purchasing their fuels freely in the open market at the lowest possible price, and without preferences being given to any particular kind of fuel. If the system is to operate at a profit and to produce a net minimum return on its assets, the domestic consumer must pay more if the industrial sector is to be charged less.

It is difficult to say what the effect would be if industry were permitted to build its power stations of optimum size and to purchase its fuel in the cheapest market. Economically, stations should have a capacity of at least 300 MW and for full

utilization they would have to be given the right to sell electricity surplus to their requirements to other industrial consumers, or to the area boards, at reasonable prices. At present the price is reputedly 0.4d/kWh, as against the bulk demand tariff of 1.12d. At present the economic advantages which industry might derive from these stations are lost in the Grid. The present tariff structure in the UK has been laid down by Parliament, and no reform is possible without government action.

It is nobody's business to see what happens if our industries are costed out of the competitive game because electricity costs are too high in comparison with those of our competitors. The aluminium smelter affair was an exception to the rule, which under modern technological conditions should no longer be allowed to exist. Whatever the antecedents of the aluminium business, it led to the fixing of special tariffs for the new smelters. This caught the public's imagination and faced the government with an issue it could not sidestep. On the whole, however, the public knows and cares far too little about the technological problems of the future and the effects on the balance of payments of domestic chlorine, sodium and phosphorus production, so that there is no pressure to force government action. But without government action there will be no reform of our tariff structure, and without this reform it will become impossible for Britain to compete in the new industries now being established on the Continent and elsewhere.

A new model of fundamental particles

Nobel physicist Julian Schwinger has proposed the existence of a new type of particle with both magnetic and electric charges in an attempt to explain some of the great mysteries of physics

Dr Gerald L. Wick

is a nuclear physicist at present working as a free-lance scientific journalist

The modern physicist's concept of the basic building blocks of matter is in a constant state of flux. For 100 years, before radioactive decay was discovered at the beginning of this century, the atom was firmly established as the indivisible constituent of matter. Then, by investigations of cosmic rays and the invention of high-energy particle accelerators, sub-nuclear particles were discovered.

No clear hierarchical structure was apparent, however, until 1964 when a classification based on the so-called Principle of Unitary Symmetry (SU(3) symmetry) was proposed as a result of a remarkable international effort involving physicists from Japan, Pakistan, Italy, Israel and the USA. One of the physicists, Murray Gell-Mann of the California Institute of Technology could explain this subnuclear periodic table by inventing hypothetical particles called "quarks". Using the quark model Gell-Mann predicted the existence of the omega-minus particle which was later observed experimentally, but in the opinion of most experts no quarks have definitely been detected in spite of recent claims (see "Monitor", p.510).

New investigations into the primordial particles of nature are now being conducted by Julian Schwinger, the Nobel Prize physicist from Harvard University. Combining some features of the quark model with assumptions about the magnetic pro-

perties of matter, Schwinger has hypothesized a new set of fundamental particles called "dyons". The name "dyon" was selected because one property of these particles is that they possess a double charge—electric charge and magnetic charge. Schwinger hypothesized the magnetic charge in an attempt to explain one of the mysteries of physics which can be traced to the famous equations of electric and magnetic fields derived in the last century by the British physicist, James Clerk Maxwell. These equations exhibit an intrinsic symmetry between electric and magnetic quantities; but no magnetic counterpart to electric charge has been observed experimentally.

Experimenters have searched for the so-called magnetic charge or "magnetic monopole" in many materials, including sediments from the ocean floor, but with no success. At present Moon rocks are being investigated as a source of trapped magnetic charges but most physicists are not very hopeful of positive results. Matter has always been observed to be magnetically neutral and all attempts to separate a north magnetic charge from a south magnetic charge have met with failure.

More than 35 years ago another British physicist, P. A. M. Dirac, discovered that if magnetic charges exist, it follows from the laws of quantum physics that electric charge can exist only in integral

multiples of a fundamental unit charge—that is, in quanta. This discovery threw light on another of the great mysteries of electromagnetic phenomena—namely, why do all charged particles possess an identical charge despite wide variation in their other characteristics? The existence of magnetic charge would answer this question.

These issues, plus important related problems, were raised recently by Schwinger. The existence of dyons would clarify the magnetic and electric charge problems, and also offer explanations for the structure of the artificially created subnuclear particles. Furthermore, Schwinger's model can account for the famous experiments on K mesons which show weak violations of the general symmetry property of matter where the left and right are interchanged (parity) in combination with the exchange of positive and negative charge (charge conjugation). The physicists call this phenomenon CP violation. Schwinger says that his hypothesis "has in its favour only one argument—that it does connect and give tentative answers to all these questions" (*Science*, vol. 165, p. 757).

The dyons were hypothesized to be the basic building blocks of all fundamental particles. Schwinger derived the properties of the dyons using constraints of the theories of relativity and quantum mechanics and the observed properties of the fundamental particles. The main new assumption was that dyons possess both electric and magnetic charges.

Under these conditions Schwinger was able to give some quantitative results. He found that the forces between magnetic charges are stronger than strong nuclear forces by a factor of over 400. This could account for the difficulty of separating magnetic charges. Another result was that when two or more dyons are formed into an aggregate particle which is magnetically neutral, the quantum condition of electrical charges follows as a natural consequence. Schwinger's estimate of the dyons' mass is approximately 6GeV (thousand million electron volts).

Although he was cautious about quoting this number, it is optimistically within the capacity of current accelerators' energies, and may encourage experimenters to take up the search.

The strange thing about dyons is that they must possess a fractional part (either $\frac{2}{3}$ or $\frac{1}{3}$) of the basic electric and magnetic charge in order to be the constituents of elementary particles. This is reminiscent of the "quark" model devised by Gell-Mann. The quarks also have fractional electric charge, but are magnetically neutral. Schwinger explains that the properties of quarks can be traced to the basic symmetry of electric and magnetic charges plus the requirement of magnetic neutrality. Gell-Mann has said that quarks were invented for their mathematical convenience and may not exist in nature. No one has searched for dyons, but they could also be just a mathematical device.

Schwinger also suggests a notation for dyons and an explanation of how they combine to form elementary particles. A dyon of magnetic charge $\frac{2}{3}$ and electric charge $-\frac{1}{3}$ is written

$$\frac{2}{3}D-\frac{1}{3}$$

In order to satisfy the constraints imposed by the properties of elementary particles, such as angular momentum, particles like mesons are composed of two dyons and particles like protons and neutrons are composed of three dyons. For example, an electrically neutral meson could be represented as

$$\frac{1}{3}D-\frac{1}{3}+-\frac{1}{3}D\frac{1}{3}$$

A meson with one positive unit of electrical charge could be

$$\frac{1}{3}D\frac{2}{3}+-\frac{1}{3}D\frac{1}{3}$$

The antiparticle of this meson would have one negative unit of electrical charge

$$-\frac{1}{3}D-\frac{2}{3}+\frac{1}{3}D-\frac{1}{3}$$

Note that the magnetic charge always adds to zero. A proton could be formed of three dyons with magnetic charge $\frac{2}{3}$, $-\frac{1}{3}$, $-\frac{1}{3}$. Of course, the electric charge must add to +1. Only three dyons and their antiparticles are necessary to represent all the elementary particles and their intrinsic properties. However, in order to reproduce all the properties of the subnuclear particles, such as angular momentum and isotope spin, the aggregate states of the dyons are more complicated than the sample examples presented here.

As electric and magnetic charges behave oppositely under spatial reflections (parity), and as the equations of electromagnetism are symmetrical between positive and negative charges (charge conjugation), the mere existence of doubly charged particles violates CP invariance. Unfortunately CP violation as observed in K meson decay is very weak and the dyon model provides for a large violation of CP symmetry. Schwinger's explanation for this paradox involves the rapid appearance and disappearance of another particle of unit magnetic charge through the processes of the type

$$\frac{1}{3}D-\frac{1}{3}\leftrightarrow-\frac{1}{3}D-\frac{1}{3}+1S^0$$

The particle S (for strong) is called a boson and does not affect the dyon's electrical properties but exchanges magnetic charge between two dyons. For symmetry there would be a boson, W (for weak), which exchanges a unit of electrical charge

$$-\frac{1}{3}D\frac{2}{3}\leftrightarrow-\frac{1}{3}D-\frac{1}{3}+0W+1$$

The W boson had been hypothesized several years ago as an intermediate state in events such as beta decay of nuclei. The W and S particles may be fictitious but events involving S would occur much more often than events involving W due to the superstrong forces between magnetic charges. Through this distinction between magnetic and electric charges, the results of the K meson decay can be explained. In an aggregate particle the individuality of each dyon is destroyed by the rapid exchange of S particles. Through this loss of identity, the CP-violating effects of a dyon can be reduced adequately to account for the experimental results of K meson decay.

The beauty of Schwinger's theory is that it unifies many assorted and apparently remote facts. Its truth or otherwise will have to wait further experimental and theoretical work.

TECHNOLOGY REVIEW

EDITED BY DAVID HAMILTON AND MICHAEL KENWARD

Predicting conflict's pattern

War is a predictable event, obeying certain rules and producing predictable results, according to John Voedodsky of Stanford University. In a paper to last week's International Cybernetics Congress in London, Voedodsky, who holds a degree in behavioural cybernetics, the first of the American doctorates in the cybernetic area, says that once warfare starts it is an orderly and repetitive behavioural event. The initiation is of course less predictable, but once a conflict has started and the first loss figures are in, it becomes possible to predict with considerable accuracy—within five per cent—what the loss rate will be. The rate will continue as long as there is no substantial weapons shift or escalation.

Voedodsky studied five wars, including the present one in Vietnam, and has been able to forecast accurately 18 months ahead what the American losses would be. What is more, he can predict when the loss rate will become unacceptable—though this part of the work has yet to be fully developed—and what the effect

will be as forces in the battle zone are increased. He points out that a doubling of the forces does not double the casualty rate, as one might expect, but multiplies it six times. The Korean war, in which casualties increased roughly four times, was an exception.

Besides that, he can calculate the relationship between the casualties sustained by each side, and also what a nation is prepared to tolerate in terms of casualties and as regards the length of time the conflict lasts.

In another paper, written by the high-ranking academician Victor M. Glushkov—but presented by a colleague, as he himself was touring Australia at the time—indicated the way in which the Russians are thinking in using computers in the natural sciences, and how they are trying to overcome the hurdle of having to use efficient, but slow, computers.

The heart of the paper was concerned with non-classical mathematical models and the development of algorithmic languages to allow scientists to use computers with ease when dealing with such subjects as biological processes. They are interested in automating

the process without having to use a computer-oriented language, which is rather far removed from the way in which the problem is stated. In effect what they are trying to do is to automate much further along the deductive chain.

The end of this line of work would be a system that would allow mathematicians, for example, to test theorems directly on computers which would tell them whether the theorem were new, and would specify its relationship to existing theorems. It would also include devising some means whereby the computer could handle the non-creative part of the work of constructing a proof.

Jet flaps for whirling wings

Work on jet flaps to improve the lift of wings at low speed, which has been in progress for some time at Farnborough, has led to the idea of applying the principle to helicopter blades in the United States. Earlier this year the aeroplane used for the experiments at Farnborough was sent to the US at the request of the National Aeronautics and Space Administration and has since been "test flown" in a high wind tunnel. The Lockheed Corporation has latterly had under test in a smaller tunnel a 6-ft diameter model rotor in which the blades are provided with jet flaps.

In the original conception, a sheet of fast moving gas was spread from a slot in the trailing edge of the wing to serve as an invisible flap both to extend the lifting area and to change the camber of the wing in the interests of high lift at low speed. The Lockheed adaptation adds to this a slot near the leading edge of the aerofoil to blow another stream of gas over its chord to prevent turbulence and the breakaway of the airflow. This blowing system is already in regular use in the Buccaneer aeroplane designed specifically for deck landings and now serving in the RAF as well as the Navy.

Lockheed's aim in starting this line of development is two-fold. It is concerned both with high-lift helicopters and with the evolution of a type of rotor blade which can do duty for rotary lift at take-off and landing and then be stopped in such a position that the two blades can serve as conventional wings during the cruise. The design of helicopters capable of lifting unusually heavy loads is complicated by the high tip speeds which occur in rotors of big diameter. The claim made at present is that blades equipped with the jet flap generate 10 times as much lift at a given rotational speed as ordinary blades and therefore will facilitate the use of rotors of smaller diameter and with lower tip speeds.

The big Mil. helicopters in Russia have already lifted more than 30 tons at a time. The Lockheed engineers look forward to helicopters capable of lifting 100 tons. Their idea for compound VTOL aircraft is to provide jet engines for propulsion and, with the combination rotor blade and fixed wing, to design a supersonic aeroplane which takes off and lands vertically. In this application, the stream of air from the leading-edge slits will be specially valuable in preserving lift at the transitions between vertical and horizontal flight. The development programme is likely to be spread over 10 years.



Inflatable weir

A movable weir which can stop the flow of a river or canal within minutes has been introduced by Dutch hydraulic engineers. Basically it consists of a flat steel chest containing a folded nylon-rubber bladder. Until activated the weir lies on a concrete sill on the bed of the waterway, but when water is pumped into it the bladder is inflated and rises above water level. In this state it stems water flow and can be used as a temporary bridge by pedestrians and light vehicles. The weir has been devised by the Department of Waterways and Drainage of the province of North Holland, on the basis of a design by Mr J. C. Buijze, and the bladder was developed in conjunction with the department by the firm of Rubberfabriek Vredestein Loosduinen NV (PO Box 7006, The Hague, Holland). A 28-m weir of this type has been brought into use on the Weespertrekvaart canal, in the Amsterdam municipality.

Snags in jumbo's engine

How the elimination of teething snags can lead to new difficulties in preparing new jet engines for airline service is shown in the account of modifications recently made in the engine specified for the Boeing 747 jumbo jet. This engine, the JT9 D-3, showed a tendency to surge on deceleration in the course of trials in a bomber during the past year. To cure this, the designers altered the relation between compressor and turbine to secure a better flow. At the same time a special ring was fitted to the nozzle of the fan with the object of improving the quietness rating.

One result appears to have been a heavier consumption of fuel, reported as equal to an increase of five per cent in the amount of fuel needed by the 747 on a flight between New York and Paris. The makers have since modified the compressor and say they have restored the original specific fuel consumption rate so that the production engine will now meet the specification in full. Nevertheless, the changes have caused some anxiety to the makers of the 747 on the score of getting the new liner certificates in time to keep their delivery dates.

Airliners without engines are being rolled out of the assembly hanger at the rate of one every five days and are having to be parked until the modified engines arrive. An airworthiness certificate is needed by October so that the earliest deliveries can be made to Pan-American which has announced a firm date of 15 December for the opening of its daily jumbo service

between New York and London, to be followed three days later by daily flights to Paris. It has also announced the opening of services between Los Angeles, Honolulu and Tokyo on 6 February.

This engine has been in development since 1966. It develops 43 500lbf static thrust and, in a later mark, this is likely to be increased by 2000lbf with the help of water injection. It is a relatively quiet engine and because of this Boeing have promised that the 747 will be six to ten decibels quieter than present airliners.

Undersea tunnel to link Japanese islands

The world's largest undersea tunnel—the Seikan—is now being built in Japan. Due to be completed within six years, it will be 36 400 metres long, with a 14 400-metre undersea portion. The tunnel will link the central mainland of Honshu with the northern island of Hokkaido, cutting the time taken for the journey from four and a half to two hours.

In 1964, 18 years after the first surveying work was carried out, engineers started digging exploratory tunnels. They have already dug two slanting shafts, each over 1200 metres.

The southern side exploration was delayed by flooding in the lower part of the tunnel. In order to forestall further flooding, a test tunnel is drilled first, 500 metres ahead of the main boring. Leaks that this test hole reveals are plugged and consolidated with cement or silicate. For the large bore tunnel a huge digger

is used that can cut a 3.6 metre-diameter tube at rates of up to 1.5 metres an hour. The project organizers—the Japan Railway Construction Public Corporation—expect that they will be able to get a clearer idea of the project's problems when they have dug horizontal research tunnels of three to five kilometres. One is being dug on the northern side.

Killing radar's echo

An idea for defeating the detection of missiles by radar is being examined in the United States. It is based on the belief that the reflection of the radar beam from the surface of the missile can be attenuated by setting small aeriels in that surface to radiate energy capable of neutralizing the electrical fields responsible for the "echo". In other words the echo would be smothered before it could be emitted or, if not obliterated, then so reduced in strength as to be of little value.

Radar has had to find ways of overcoming difficulties from the beginning. It has had to make extravagant use of power and has had to overcome spurious reflections by developing the moving target indicator. It was long in finding a way to determine the height of targets and that process is still expensive. Many attempts have been made to treat surfaces in such a way as to prevent them from reflecting the radar impulse. The latest investigation, which could roughly be compared with the degaussing of ships' hulls, represents a new approach.



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External links for integrated circuits

Microcircuit engineers find that one of their major problems is connecting the circuits with the outside world. Ron Brown explains the techniques which they can call upon to do so

Connections are the weak links in the integrated circuit. At one time they were manually soldered to the IC using techniques similar to those used with discrete components. But manual soldering is far too time-consuming, costly, and unreliable, and several alternative techniques are now practised.

The oldest of these is known as the "flip-chip" method. A newer and very promising technique uses what are called "beam-leads". A third technique employs what is known as "spider bonding". That there is very little agreement in the industry about the relative merits of these techniques became very clear at the International Electronic Circuit Packaging Symposium, held recently in San Francisco.

The trouble with conventional soldering of wires is that the wires pull away from the integrated circuit under stress. The answer is clearly to do away with wires altogether, which is just what the new methods achieve. In the flip-chip technique, which has been in use for about six years, metal balls coated with solder are fixed to the contact pads before the integrated circuit is put into place. These balls are in electrical contact with the external leads to the circuit. The integrated circuit itself is placed upside down on to the contact pad in such a way that a solder-coated ball is immediately underneath each point on the circuit to which an external connection has to be made. The integrated circuit chips are then heated until the solder melts and forms a permanent connection. IBM has been using a modified form of this technique, called solid logic technology, in its 360 series of computers.

Flip-chips, however made, are much more reliable than conventional wired devices. A study carried out by the United States Air Force has shown that conventionally wired devices have a failure rate of 0.00013 per cent per 1000 hours. Flip-chips plus close process control lowered the failure rate to an estimated 0.00001 per cent per 1000 hours.

The economic attractions of flip-chips are also quite impressive. The labour content

for a flip-chip device is said to be only 3.2 cents, against 11.6 cents for a conventionally wired device.

Among the advantages of flip-chips are that the bonds formed are very strong and the process fits in very well with present-day production methods for integrated circuits. Unfortunately, great precision is required in printing the substrate if the size of the flip-chip is to be kept to a minimum. An even more serious disadvantage is that because the bonds lie between the integrated circuit chip and the substrate they cannot be seen during inspection and are not easily repaired.

Another great snag with flip-chip methods is the need for high heat and pressure levels, although some people in the industry rather discount the stress produced. The key point seems to be the number of connections that have to be bonded. As might be expected, the force required to squash the solder bumps into acceptable bonds increases with the number of bumps. Beyond a certain point the force required must inevitably make the integrated circuit suffer. As many as 50 leads have been bonded to a flip-chip, but some say that 16 leads may be the upper limit, which rather rules out the method for medium- and large-scale integration.

If greater reliability, or more leads, are required the beam-lead method appears to be better. In this technique no heat or pressure is needed to make the bonds. The connections are even less likely to break under stress, and there seems to be no limit to the number of leads.

This method was pioneered by Bell Telephone Laboratories. The interconnections are made from gold leads, or "beams", about 12mm thick. The gold leads are electroplated onto the exposed terminal points and extend beyond the boundaries of the integrated circuit, like a cantilevered beam, to connect the circuit to the external world.

One major problem is separating the individual integrated circuits after the beam-leads have been formed (many hundreds of integrated circuits are formed on a single silicon wafer and separated at the end of the production line). One way of doing this is to coat the silicon wafer with wax on the same side as the beam-leads. The integrated circuits are then

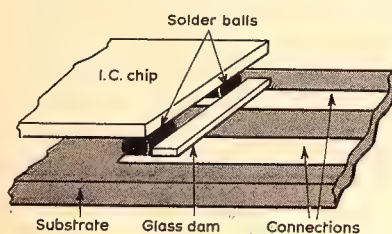
separated by etching through with acid from the other side. Bell Systems claims mechanical yields of better than 99 per cent and electrical yields better than 90 per cent with this process. The beam-lead technique was given a tremendous boost recently when it was selected for use in the US Army's Sentinel anti-ballistic missile system.

Among the other advantages of the beam-lead method is the fact that the leads are visible. Against this must be set the cost of the gold and the added processing steps, and the fact that the beam-lead devices take up a lot of space. Beam-leads can certainly double and may treble the costs of an integrated circuit, a state of affairs that will continue for some time.

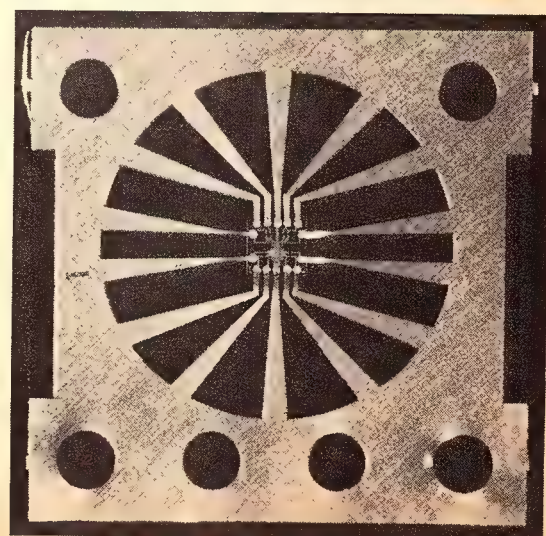
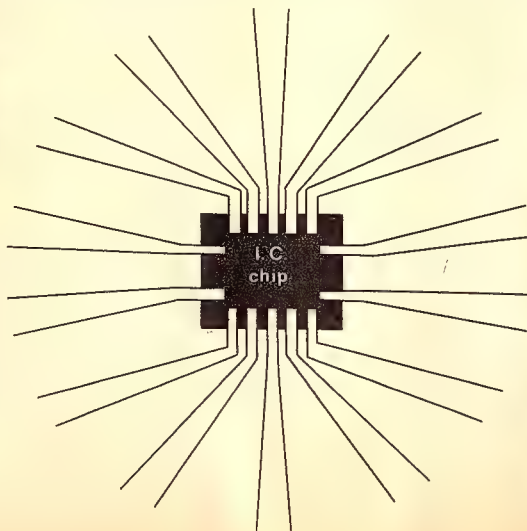
An idea of the reliability of the beam-lead technique may be gained from the fact that Motorola has been unable to find a centrifuge that will pull the bonds apart. This is quite something when it is realized that centrifuges can spin the devices at up to 100 000g. All indications are that they are the most reliable and stable semiconductor structures ever produced.

Costs may come down. For example, quite recently a radically new kind of beam-lead device using aluminium and a much simpler separation process has been produced. Motorola's spider bonding method, announced last year, is cheaper than beam-leads, although not so reliable, and is 20 times faster than connection wire bonding. It is ideally suited to automatic production. The connection "spider" is stamped out of an aluminium strip. Spiders and IC are brought together, and an automatic ultrasonic bonding machine then completes the job. Beam-leads, flip-chips and spider bonding may prove to be complementary techniques.

Whether these techniques represent the final answer is another matter. The American General Electric Company is known to have developed a new type of bond called "semiconductor on thermoplastic on dielectric" or STD for short. A few details of this process were published about 18 months ago but shortly after that the Pentagon put the process on the secret list, which would seem to indicate its importance. Whatever happens it is certainly clear that microcircuit engineers would be very glad to be free of the problems facing them.



IBM's new variation of the flip-chip technique, using solder balls instead of solder-covered copper ones, with a glass dam stops solder running too freely (above). Motorola's spider-bonding technique, with the circuit held in a "spider" of aluminium (right), and a photograph of a circuit in such a mounting (extreme right)



Rugged radio frequency standard ammeter

The aerospace industry, for one, needs to measure accurately current flow at high frequencies—to calibrate current probes in missiles and space vehicles, for example, or to measure currents in the aerial elements of aircraft instrument landing systems to ensure that they are working properly.

When the National Bureau of Standards, in Washington, developed an improved standard for high-frequency current it decided that a secondary standard was needed to transfer accurate current measurements from the NBS standard to users in industry and science. A dynamometer similar to the primary standard would be too large and expensive. W. W. Scott of the NBS Institute for Basic Standards has devised an ammeter that represents an accurate, rugged and portable transfer standard.

The new ammeter consists of a silver cylindrical reflector, elliptical in cross section. A heater is mounted along one focus, and a sensitive thermopile along the other. The heater emits infrared energy when heated by dc or radiofrequency input current. This infrared energy heats the thermopile, which consists of about 80 thermal elements wound in electrical series and in thermal parallel on a special quartz frame. This design was adopted to give the thermopile both a sizeable output and fast response—an unusual combination.

Tests carried out on the prototype ammeter indicate that a direct current ranging from 0.5 to 5.0 amps passed through the heater pro-

duces a thermopile dc output ranging from 1 to 100 millivolts, which corresponds to heater temperatures of about 33 to 500°C. The heater is not destroyed until the current reaches nine amp. The frequency range of the ammeter is dc to 1GHz. (More information from NBS Technical Information Office, US Department of Commerce, National Bureau of Standards, Washington, DC 20234, USA.)

Stretching stronger cotton

Cotton fibre or cloth has both lustre and strength improved when it is dipped in pure liquid ammonia. J & P Coats Ltd of Glasgow have adapted the ammonia treatment to produce even stronger cloth.

The liquid ammonia is removed from the fibre by heating. As the ammonia is evaporating the yarn or fabric is stretched, by 10 to 30 per cent. The actual amount that the cotton is stretched will depend upon the effect desired. The increase in strength can, in special circumstances, be appreciably greater than the 40 per cent that is usually achieved with this stretching technique.

The traditional mercerising process—a caustic soda dip—gives a maximum strength increase of 20 per cent. There is the added drawback that if the caustic soda is not completely removed from the cotton then the fabric will gradually rot.

The ammonia treatment also reduces the extensibility of fabrics which means there is less tendency for cloths to pucker when stitched. The improvement in strength means that

finer sewing threads can be used to give a particular garment strength. The process is covered by British patent 1 136 417. The company is now considering licensing processors in various countries to use the technique. More details from J & P Coats Ltd, 155 St Vincent Street, Glasgow C2.

Saving cars from lorries

Motoring accidents in which cars slam underneath lorries are generally quite severe. A common type of crash is where the front of a car passes under part of a truck or trailer, slicing off the top of its passenger compartment. The US Federal Highway Administration has awarded a \$207 445 contract to Cornell Aeronautical Laboratory to develop a system to prevent this under-ride collision.

Cornell will draw up safety standards for car bumpers and guards for lorries, with the aid of a computer to simulate collisions, and will design two types of under-ride guard for heavy lorries, and two types of car front bumper. The guards will be arranged to act as a "fender", and will be equipped with energy-absorbing devices to cushion the impact.

A series of 8 to 15 crash tests will be carried out on a variety of cars, including tests under severe braking conditions involving pitching, or nose diving, of the car. The truck guard will be mounted on a standard crash barrier at various heights. If necessary, impact tests will also be made with a lorry. The car bumpers may also be tested by crashing two cars together.

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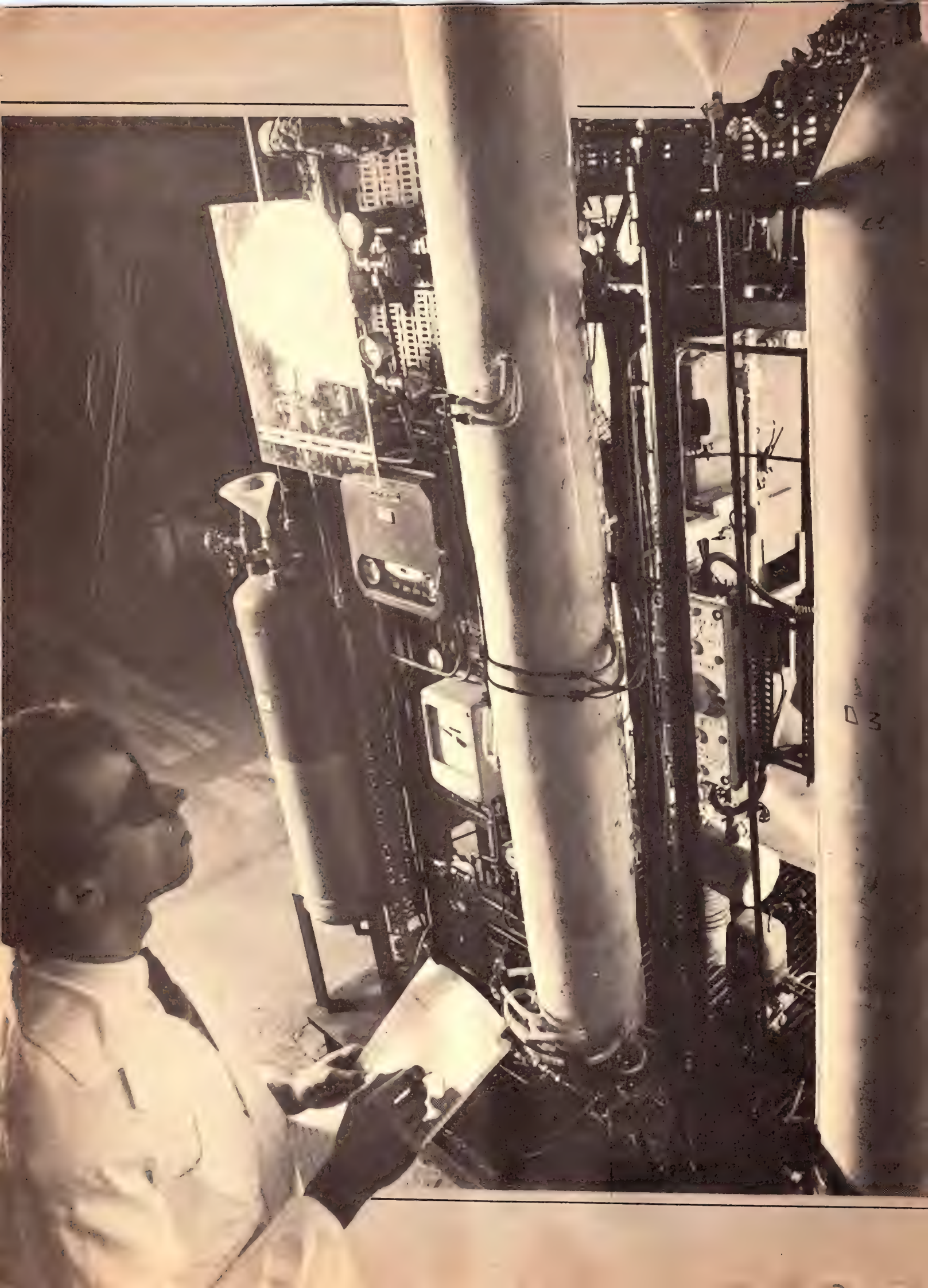
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von Humboldt: explorer of a new world

The life of Alexander von Humboldt, who died 200 years ago this week, provides a striking demonstration of what can be done for the organization of science even in the most trying social and economic circumstances and with modest financial resources

J. G. Crowther

is a former director of the science department of the British Council, and was for 20 years science correspondent of the *Manchester Guardian*. He has written many books on the social aspects of science

America was discovered in 1492. Most of its central and southern region immediately became the property of Spain, and was closed to the rest of the world for more than three centuries. During all that time this vast and unique area was scientifically almost unexplored. Then, in 1799, Alexander von Humboldt, at the age of 29, gained the approval of the King of Spain to explore his empire. This caused widespread astonishment, and proved to be one of the most fruitful political actions ever taken on behalf of science.

For long afterwards, however, scientists were interested only in the enormous inspiration and results that followed Humboldt's explorations. Charles Darwin was but one of many who attributed his scientific destiny to Humboldt: "I shall never forget that my whole course of life is due to having read and re-read as a youth his *Personal Narrative*, his account of his travels in the new continent during 1799-1804."

The contrast between Columbus, the first European to set foot in the new continent, and Humboldt, the first scientist to explore it adequately, is salutary. Columbus never realized that he had discovered America; he believed he had found the direct sea-route to the east coast of Asia. Over 300 years were to pass before Columbus was followed by a first-rate scientist with adequate opportunities. It is to be hoped that the interval between the first man on the moon and the first scientist on the Moon will be shorter.

Humboldt's success in creating the opportunity for exploring Central and South America was the first of his series of social actions on behalf of science which had major consequences. He presided at the first general meeting of scientists, held in Berlin in 1828. This became the pattern for the British Association, and all similar organizations since. His presidential address contained those broad views on the social value of science that have so often been repeated by presidents of such bodies. The sole British attendant at that meeting was Charles Babbage, who took a leading part in the founding of the British Association, after the German model, in 1831.

Humboldt's variety of interests, expository gifts, perception and encouragement of talent, imaginative grasp of scientific possibilities, and diplomatic ability enabled him to become the chief inspirer of international scientific organization. He spread the ideas which ultimately led to the International Geophysical Years and the International Council of Scientific Unions. His sustained magnetic and meteorological observations led to the first effective efforts towards the world organization of scientific observations.

Several excellent biographies of Humboldt have been written, and English readers are fortunate in having a recent one by Dr Lotte Kellner (*Alexander*

von Humboldt, Oxford University Press, 1963). There still remains, however, scope for further analysis of Humboldt's personality and his social and political activities, to gain more insight into his extraordinary creative power as a statesman of science. It is this quality on which more insight is needed to throw light on contemporary problems of guiding scientists and scientific civilization.

Alexander von Humboldt was born on 14 September 1769. His father was a Prussian officer who became chamberlain to the brother of Frederick the Great. His mother was a wealthy woman of Huguenot descent. She inherited a castle twelve miles north of Berlin, and this became the family seat of the Humboldts. She was a cool, dominating woman. Humboldt said that they were forever strangers. He was warmly attached to a series of gifted men, beginning with his elder brother Wilhelm, an eminent scholar and founder of Berlin University, now named the Humboldt University, after the two brothers; and later on to Gay-Lussac and, above all, to Arago. He was irresistibly attracted by genius, but he never had more than intellectual relations with women. He and his brother were carefully educated for positions in the state, Wilhelm for a high one, but Alexander, who was a slow learner, for the civil service.

One of his tutors brought him in touch with Moses Mendelssohn, the self-taught emancipator of the German Jews from the ghetto. Mendelssohn's house became a unique cultural centre, in which the Jewish ladies participated on terms of intellectual equality. Humboldt subsequently banked with the financial side of the Mendelssohn family, who accommodated him through his long life with far more than ordinary consideration.

Private fortune used for science

The Humboldt brothers were excited by the French Revolution. Alexander was in Paris in 1790, just before the first anniversary celebrations of the fall of the Bastille. He was permanently influenced by the experience, and always regarded himself as a man of 1789. Fifty-nine years later, at the age of 79, he was a leader in the funeral procession of the trade unionists killed in the Berlin revolution of 1848.

Yet for more than 50 of these years he was a personal adviser and representative of kings of Prussia, who allowed him a small salary, which enabled him to devote his private fortune to science. How Humboldt succeeded in preserving good relations for so long with such a range of divergent personalities and social classes is one of the most extraordinary phenomena in the history of science. No adequate explanation of it has yet been given, but the example is of prime importance.

Dr Kellner describes him as pre-eminently a child of the age of enlightenment, cosmopolitan and

Self-portrait of
von Humboldt
(pencil drawing of
1814)



multilingual, but also a loyal German. He preserved his independence by living modestly, and paying sufficient respect to the authorities without setting a high value on their rewards.

As the apparently less talented of the two brothers, Alexander was forced to learn economics. He did not become interested in science until comparatively late. He was sent to study industrial processes, and in 1789 went to Göttingen. There he found as fellow-students the future King of Hanover; the Duke of Sussex, the Duc de Broglie; and Prince Metternich; acquaintances not without subsequent use. He wrote a dissertation on Greek and Roman textile looms, using his technical knowledge to interpret classical technical terms. His classics professor was Heyne, whose daughter had married George Forster, the son of Captain Cook's naturalist on his second voyage round the world. Forster had accompanied his father, and his accounts of the results of Cook's voyage fired Humboldt's interest in travel and aroused in him a passionate desire to engage in scientific exploration. He taught himself some chemistry and physics, and improved his knowledge of geology and mineralogy. He went to study under A. G. Werner in the famous Freiburg school of mines. The course was very strenuous, and he learned to do technical and scientific work for long hours under trying conditions.

In 1792 he was appointed an inspector of mines. He carried out his duties with extraordinary energy, going down the pits, and personally supervising the workings and assaying. He invented a safety lamp which was used until superseded by Davy's, and a gas-mask. He tested these himself in disused workings filled with fire-damp, and was on occasion carried out unconscious.

His concern with physiology led him to experiment on muscle and nerve. He concluded that the nerves produced a substance which on entering the muscle caused it to contract. He investigated the effects of gases on animals, using the frequency of the heart-beat as an indicator. He discovered that breathing will stop if the concentration of carbon dioxide exceeds a certain limit. He placed electrodes in an open wound in his back to observe the effects of the electric current on the secretion of serum and blood, and whether pain could be deadened by over-stimulation of the nerve.

As a mining engineer and scientist he already showed remarkable capacity for withstanding fatigue and pain. Later he suffered severe hardships in exploring the Orinoco, in a boat hollowed by fire and axe from the trunk of a tree. A crew of four, together with scientific instruments, books, birds and monkeys was packed into it, and they paddled on through clouds of gnats and mosquitoes. Humboldt's right arm was permanently impaired, and in order to write he had to lift his right hand with his left, making an almost indecipherable scribble. Yet

his accounts of his explorations alone ran to more than 20 volumes, and his *Cosmos* to five.

His mining work stimulated research on magnetism. In 1796 he discovered reversed magnetic polarity in rocks, one of the basic data of geomagnetism. Later on he discovered magnetic storms. Through his researches on mine atmospheres and the magnetism of minerals he perceived the need for systematic observation of the earth's atmosphere and magnetism. He already proposed the setting-up of networks of stations, covering many countries, for this purpose.

At the same time, he sought indefatigably for an opportunity for scientific exploration. All arrangements had been made for him to join a grand French five-year expedition of world exploration, supported by Napoleon. This fell through, owing to the financial exigencies of Napoleon's invasion of Egypt. Humboldt tried to go to North Africa, but without success. He went to Spain, hoping to find a ship for Turkey. He took systematic barometric readings on the way from Catalonia to Madrid, and discovered that Madrid was on a plateau, which was previously unknown. This scientific discovery impressed the Spanish authorities and contributed to their decision to give Humboldt permission to explore Spanish America.

Founder of plant geography

In the course of his 6000-mile journey he systematically mapped the intensity of the Earth's magnetic field. This was the starting point for Gauss's mathematical, experimental and organizational work on magnetism, though he would not admit it. Humboldt in his account of the flora founded plant geography. His observations of the Andes led to new conceptions of the role of volcanoes and the structure of continents, and his recording of the temperature of ocean currents to the development of oceanography. Combined with all this was new information on languages and archaeology, and the Aztec and Inca civilizations.

Humboldt's wonderful journey gave him an appropriate reputation. In 1807, when he was 38, he was asked to accompany the Crown Prince to Paris as equerry. The King presently made him his personal representative, and Paris was his headquarters for the next 20 years. His diplomatic duties involved peace and other negotiations. During the difficult time of the fall of Napoleon he was able to protect French scientific institutions from allied depredations. He accomplished his scientific researches by working through the night, sleeping only about four hours.

He joined Berthollet and Laplace in the famous scientific society at Arcueil. Every young scientist visiting Paris aspired to call on, and be helped by, him. Among them was Liebig, the founder of organic chemistry, who was primarily indebted to Humboldt for his career.

After completing the account of his American travels Humboldt left in 1829 on another major expedition, to Russia and Central Asia. It was conducted in a blaze of publicity and honour. His influence with the Russian authorities and the Tsar had very important consequences. On his recommendation the Russians built, within five years, a

von Humboldt: explorer of a new world

chain of meteorological and magnetic observatories across Siberia and in Alaska. This was the first planned construction of scientific stations on a continental scale. In 1836 Humboldt wrote to the Duke of Sussex, his former fellow-student who had become president of the Royal Society, suggesting that the chain should be extended through the British Empire. This stimulated the Royal Society's interest in international scientific collaboration, and the world organization of observatories.

In his writings Humboldt aimed at giving synoptic views. He accomplished this on the grand scale in *Cosmos*, the first volume of which appeared in 1845. He outlined the contemporary knowledge of the universe, and consciously described it in a style that could be understood and appreciated by the intelligent reader without special scientific knowledge. It was the kind of endeavour which is essential if mankind is to be provided with a general grasp of its place in the increasing scientific and

technological world. Humboldt distributed the proofs of *Cosmos* among his friends. He sent a set to Sabine, who pointed out that Humboldt's data on magnetic storms showed that these were related to the sun-spot cycle.

Humboldt, like Newton, was a small man, rather unimpressive until he began to speak. Then, as Pushkin is reported to have said, he spouted brilliant talk like the sparkling water from the marble lions of a fountain. He died on 6 May 1859, just before his ninetieth birthday.

Today, the special interest of Humboldt may be his demonstration on how much can be done for the organization of science even in the most difficult and unpromising social and political situations, and with modest financial resources. What he accomplished in the historical conditions of 1790-1850 would, on the face of it, have seemed impossible. It should strengthen confidence in dealing with the problems of the conduct of science in our own age.

Fanning the flame of innovation

Though large firms account for most of the spending on research and development, brilliant, creative invention is usually achieved by individuals or small companies. There are various ways in which the manager can foster creativity of scientists, engineers and others on his staff.

Tim Eiloart

is chairman of AIM Associates Cambridge Ltd and of Cambridge Consultants, Ltd

A perfect creative engineer will be a paragon, no doubt. One who is merely very good indeed may tend to be wilful, volatile, obsessive and eccentric, with a strong aptitude for improving everything he sees. These are character traits that poorly suit most organizations. Indeed, the spirit of free inquiry is contrary to the very concept of organization. Large British R & D labs *must* make good use of such people but on two counts such labs seem to be failing in this objective. In the first place more than 80 per cent of brilliant, creative invention comes from individual inventors or from inventors with their own small companies. It appears that from about 5 per cent of the expenditure on R & D we get 80 per cent of the breakthroughs—not a random 5 per cent but the shoestring 5 per cent. This poor performance of large labs is the same the world over.

The second blot on Britain's particular record lies in the employment of engineers by large organizations. In numerous surveys, Denis Pym (*New Scientist*, vol.36, p.485) has found a vicious circle of bad-driving-out-good in such companies. Briefly this takes the following form: all incoming graduates are poorly led. The good ones leave. The poor ones remain and due to their experience some of them have to be promoted. They make bad leaders. Their highly rational background is little help to them as managers. They interfere with their subordinates, withhold information, and ask for data they neither need nor use.

Of course there are many reasons which help to explain why this should be:

1. There are too few engineers, they are often led by unqualified people, and they are not even as good as they might be. Britain educates three times as many scientists as engineers, but needs three times as many engineers as scientists. We boast a

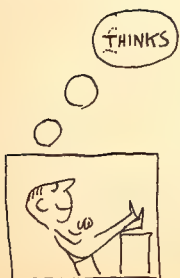
brilliant scientific community but this is little help to our material well-being or balance of payments. In Britain a minority of directors is technically qualified, but in most competitive countries many more are so qualified. The "scientist" has long been a glamorous figure when compared with the "engineer", a man with a spanner and oilcan in many schoolboys' minds. Surveys show that even the small number of engineers we do educate are a below-average sample of schoolboys. Careers guidance is abysmal.

2. A further reason why we in Britain may be decades behind the USA in our employment practice is that we have very few young, vigorous science-based companies, of the sort that might help to force all engineering employers to adopt better employment policies. Why this shortage? In the field of scientific instruments we have more large companies than small. The USA has five times as many small as large. (A "small" company is one with fewer than 100 people.) Investment by the very rich in such companies escapes income tax in a vital way in the USA—much of it is lost but the gamble is often worth taking. Britain has, moreover, very egalitarian salaries but a most uneven distribution of capital so that very few people have a few thousand pounds to invest.

3. Perhaps our tremendous literacy and our excellent television help us to be brainwashed by British advertising. All such advertising promotes security or immediate spending.

4. We certainly do not admire the entrepreneur as we used to. Our national heroes are entertainers (sportsmen, noblemen and vociferous politicians), not pioneers (merchant adventurers, salesmen, financiers and inventors).

5. Finally, there is a very sad failure even to realize the need for new engineering or techno-



logy-based companies. Yet Hewlett Packard, Volkswagen, Xerox, Honda, and several Japanese electronics companies are post-war enterprises.

Thus, for example, Professor Lord Blackett, President of the Royal Society, has suggested to the government that there is a critical mass for R & D teams. Such a team must spend (in his view) £30 000 per year, which, he argues, can only be 5 per cent of an organization's turnover—that is, "do not invest in R & D by little companies with a turnover of less than £600 000; they cannot make it". If 2000 hours cannot be found for R & D, then any project is indeed unlikely to succeed but a real enthusiast can find this amount in his leisure hours spread over one year. I do not think we can hope to optimize the funding of R & D by simply cutting out investment in tiny enterprises. Even if a project is too large for an enthusiast to handle in his spare time, the fact remains that by working twice the hours and three times as effectively as their fellows almost any team of R & D workers (down to a "team" of one man) may be able to achieve miracles.

This is the problem. How can we deal with it? Where the image of pioneers and engineers is concerned, the government has probably got to think over a period of more than 10 years. That is the length of time that it could take to bring about a genuine change of national ideals—such as has been reported in France since the war. Much of the work we need to do must be concentrated on the primary schools.

Now, what can be done at company level to foster creative drive in engineers, scientists and other qualified employees? I would like to define creative drive as one of three components in the make-up of a good engineer. The other two are knowledge and ability with people. Some components of creative drive are originality, serendipity, enthusiasm, curiosity, resourcefulness, opportunism, stamina, flexibility, dedication and energy.

There appear to be two prevailing attitudes to creative drive. The optimistic attitude supposes that these energies are waiting to be unleashed in everyone. Sort out the man's working situation, the argument goes, and you will find him bursting with creative drive. Call this the "floodgate" model. I doubt if the right working situation alone is enough. The emotional soil is just as vital as the rational rain. A man with a miserable sex life may well prove unresponsive to all sorts of careful spurs and carrots (ranging from his pay to Management by Objectives or Sensitivity Training) arranged by his employers.

The second, more pessimistic, model is that creative drive is not a dormant flood resident in everyone but merely a seed. It needs to be watered early in life. The seed may be revived or slightly nourished after leaving school, but really by that stage the game has been won or lost. There is indeed some evidence that creativity may be fostered by parental trust and support, and drive by uncertainty and trauma in one's childhood.

Recent practical work convinces me that the floodgate model is at least true in part—which may be encouraging for employers as they are involved too late to do much about the seed model. Should

the employer open the floodgates? If so, how? I have no doubt it will pay him to do so.

Given that it is worth releasing a man's creative drive, here is a list of methods that can be employed to do so; for the organization, the engineer himself, and the leader.

The organization

1. Objective setting is so widely advocated that I will not go into the advantages here. It is very helpful to have deadlines, plans for all stages and costs of an R & D project, rapid and precise feedback, and a careful plan of how new work is to play a part in the organization's five-year plan for profit growth, cost reduction, increased market share, diversification or whatever. Almost any action taken to improve R & D performance can be part of a Management-by-Objectives programme.

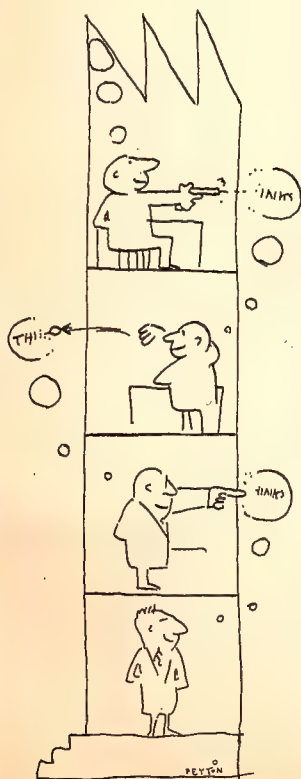
2. It is as well to have very flat management hierarchies. Each senior man can coordinate the work of many juniors. He should abandon ideas of controlling his subordinates. They may need help in selecting priorities but they will resist autocratic direction.

3. Administration also needs careful planning. Often engineers are maddened by idiotic practices designed to prevent fraud (stores procedures), costs (detailed cost allocation of every photocopy and telephone call, shortage of typists, lousy food), and to make for easy running (a lock-out at 5 p.m., cancellation of heating when production goes home).

4. What is not generally realized by graduate engineers is that a successful project is almost always the work of a man, or a team, who sees the whole job through. The problems don't end until the relevant product, equipment or process has been on stream for several months. University teaching quite rightly concentrates on analytical, mathematical and design skills. These cannot be picked up from books easily and the mastering of a difficult discipline almost certainly helps immensely to give a graduate confidence. As a result of this university concentration on the hard part, far too many graduates think the easier part of project can be shrugged off for less able people to complete. Not so. The less able people will come up with a far-from-the-best solution at every step.

5. A counterpart for (4) is that a number of non-graduate assistants should be on call or attached to the team. Otherwise another type of frustration sets in—the graduate is washing his own bottles, drawing his own details, testing his own pilot runs even when all is well, and so forth. He must be free to delegate the drudgery. Even here he should be aware that production drudgery is often a waste of money. It might have been designed out in the first place. A little drudgery will often act as a powerful stimulant.

6. A reasonable attitude is needed to pet projects, that is, new ideas that the engineer wants to try out even if they are not immediately relevant to the task he has to do. Very often such projects die after very few hours' effort and those which do not may well prove to be money-spinners. The really free laboratory, in my experience, does not actually foster obsessive and time-consuming projects.



CHECK LIST—Creativity and problem solving

1. List properties and attributes—change them.
2. State the problem clearly, try new statements, define sub-problems, define similar problems and master problems.
3. List defects of current methods, basic principles, assumptions.
4. Draw fantastic, biological, ecological, chemical, molecular *analogies*, etc.
5. Model mathematically, hydraulically, electronically, mechanically, etc. (a model is more accurate than an analogy as a representation).
6. Try different *physics*—gas, liquid, solid, gel, foam, paste, etc.
 - heat, magnetic, electric, light, shock, etc.
 - different wavelengths, surface properties, etc.
 - transitions—freezing, condensing, curie point, etc.
 - effects—Joule-Thompson, Faraday, etc.

For other problems try different approaches e.g. from the relevant field, chemistry, economics, etc.

7. Identify *variables*, interdependence, paths of communication, logical connections.
8. Ask several complete *ignoramus*es for their opinion.
9. *Brainstorm* in groups—especially drinking groups—listing any and every idea without criticism.
10. Define “nationalist” solutions (canny Scots, thorough Germans, rich Americans, multiple Chinese, etc.).
11. Sleep on it, run, walk, take a bath, swim, ride, drink, (play) squash, tennis, etc.
12. Wander through *stimulating* environments (junk yards, science museums, Woolworths; hunt through libraries, journals, comics).
13. Draw *matrix* of cost, size, relative motions, types of physics, and so on, for different solutions or different components of the problem and hunt for gaps or new combinations.
14. Identify *ideal* solution, work towards possible solutions.
15. *Distort* the problem in time (faster or slower), size, viscosity, etc.
16. *Climb inside* the mechanism figuratively.
17. Define alternative problems and systems that remove a particular link from the chain, i.e. do something *quite different* and sidestep the problem.
18. Whose problem is it? Why his?
19. Who thought of it first? What is the *history*? Which false preconceptions crept in?
20. Who else had this problem? What did he do?
21. Define current *boundary conditions* and reasons for them.

7. I have heard it suggested that a good, relaxed place to eat is the key feature of all centres of excellence in any field, whether artistic or technical.

Developing the engineer

Apart from these methods of improving the lot of the engineer it is very desirable to train him in his own discipline and in other matters.

8. Creativity itself can almost certainly be fostered by practice and a little less mystique. A check list of some of the popular methods of solving problems, for example, may be used (see table).

9. So far as drive is concerned, the problem is not so easily tractable. Many of a man's difficulties may be domestic or psychological. In Britain it is often reckoned as interference even to offer help in these areas. We may be well on the way to eliminating “them-us” problems, but “work-play” distinctions are barely ever recognized as harmful yet. Incidentally, the people with drive have been found to be those who set themselves difficult but not impossible targets in anything they do.

10. Militant and aggressive enthusiasm may be deliberately engendered and then kept at a high pitch for long periods. Techniques for doing this will be apparent to those who are prepared to interpret psychological studies on the subject, for instance, Konrad Lorenz's *On Aggression*. Sales directors often appear to use these techniques, even if unwittingly.

11. Yet another vital problem is the question of what R & D is. Too often the definition is far too

narrow. The engineer should be employed as a strategist, not a tactician. He will need to be told this and shown the way, if his education is conventional. Any project may fail for any reason. The engineer must be concerned with all the possible causes of failure, not just technical ones. Indeed, he has got to learn the discipline of hunting for the weakest link at every stage, and testing that link, no matter how nervous he may be that it will break and his project fail.

Take the example of a personal air transport. Some of the difficulties, which many might feel lie outside the R & D field, are concerned with airworthiness, air control regulations, travel patterns, airport locations, marketing, cost, choice of type (planes, autogyros, airships), foul weather patterns, noise and vibration, whether part of the vehicles should be roadworthy, and the answers to many of these problems in overseas markets.

12. The educational level of all engineers must, of course, match their needs. This often means that older staff are misemployed on R & D. The very best engineers and scientists remain on top, analytically, all their lives but they are the exception, not the rule.

The leader

There are several characteristics which will help the section or group leader.

13. A democratic and consensus-seeking leader will almost certainly prove more capable than an authoritative and controlling one. The only exception is where the boss is head and shoulders above his fellows, the tasks of R & D are really quite easy, and he is popular to boot. The democratic approach will pay better wherever the work is genuinely open-ended and the people involved are really groping to obtain mastery. The type of consensus that may be obtained concerns the allocation of all resources between the different people concerned (personnel, training, equipment, space, holidays, publicity).

14. More important even than this democratic attitude is the question of the leader's own standards. He should be very competent, very demanding of himself and much respected.

15. Several other methods have been recommended for inspiring the best personal relations with engineers: be absolutely honest, criticize in private—and praise too, get project reports at meetings rather than in writing, give information and feedback quickly, show concern for their welfare outside working hours, be a friend, trust them to be productive, let them have somewhere to think in peace without appearing lazy, ensure that they have professional friends outside the company and develop their professional stature.

16. Last, but not least, it is valuable to ask employees for their views on every facet of their employment. This may take the form of regular job reviews, questionnaires, brainstorming sessions, or weekend get-togethers.

For example, almost every idea in this paper was given to me by engineers of Cambridge Consultants when I invited them to comment, on three separate occasions, on the subjects of creativity, centres-of-excellence, and employment.

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HEWLETT  PACKARD

WESTMINSTER SCENE

by Tam Dalyell MP

Questions for Sir Stanley Brown Special grants for the mathematics teachers? A suggestion for Concorde's supersonic tests

At first sight, recent events in Northern Ireland appear to sustain the objections to the use of CS gas, voiced by many of us concerned with CBW. Severe effects do not wear off nearly as quickly as the authorities would like us to believe. In particular, the main victims are not the able-bodied combatants, but the old, the weak, the pregnant, and the very young. At least 100 babies and infants, for example, in the Bogside area of Londonderry have been suffering from serious diarrhoea.

Another disturbing development was the response to those Londonderry doctors who asked for more medical information from the authorities about the long-term effects of CS gas. My first-hand information is that they were told in effect, "You jolly well ought to know how to treat cases that have been in contact with riot gas". This is far from good enough, to put it mildly.

The opportunity might be taken to undertake a proper study of the after-effects of the use of CS. There is some suggestion that delayed reaction can take place particularly when gas is used in sticky, clammy conditions such as those of Londonderry during the rioting. If anti-CBW suits have to be tested for storing in humid conditions, such as I saw in Australia, it stands to reason that the results of the use of CS in such humid conditions could vary. A study along these lines, would be scientifically and politically productive.

The priority, however, is not a scientific investigation at all. It is an urgent and high-powered inquiry as to what extent the Ulster police flouted the strict instructions given to police in the United Kingdom about the way and circumstances in which they can use CS gas. Who gave the instructions? What authority did they have? Was it that of the Prime Minister of Northern Ireland? Were the Home Office consulted? If so, why did they not make any effort to supervise conditions? If not, why not? At least, at the time of writing, these issues are blurred—which is precisely what is so worrying about allowing police forces and units to possess chemical weapons, provocative though the situation may be.

The British Nuclear Energy Society has been active in trying to persuade politicians to take an informed interest. A number of MPs have been invited to attend the Second Cockcroft Lecture, an annual event when "persons eminent in the fields of nuclear science, engineering, or power" deliver a major-think-piece. This is an honourable, legitimate, and imaginative way of wielding pressure, which I welcome.

On 15 October, Sir Stanley Brown has chosen as his subject "the nuclear power pro-

grammes". There are a number of items on which the MPs in his audience would like to hear his thoughts. First, what is the CEBG's current thinking on the structure of the nuclear industry, and in particular do they still hold to the belief that competition inside Britain's own industry is good for the nation? Secondly, what is being done to maintain the momentum of the fast-breeder reactor programme? Like the Britannia aircraft, is it in danger of being too late on the market for us to reap maximum benefit? What are the CEBG doing to encourage the pace of development, in their capacity as initial potential customer? Thirdly, the old controversy between nuclear stations and coal-fired is no less topical in its importance for being an old controversy.

Another organization doing a useful job is the British Computer Society. They have highlighted the gravity of a situation in which the implementation of computer systems in Britain will be seriously retarded, owing to the shortage of qualified computer personnel. As the Manpower Resources Committee for Science and Technology have told us, the demand for qualified scientists and technologists last year was no less than 24 per cent higher than in 1965. However, partly owing to a cyclical contraction of the age group numbers, the educational system produced only 14.6 per cent more entrants to this category. The danger signal is that the number of sixth-formers studying primarily scientific subjects plonked from 42 per cent in 1962 to 31 per cent in 1967. Any extension of this trend would be perilous. To state a problem is one thing; to put forward practical remedies is quite another. I and other columnists can go round wringing our proverbial hands about the shortage of maths teachers till Kingdom come. What does one actually do? The stark reality is that anyone who can teach a decent level of secondary school mathematics can command a salary not just larger, but probably one and a half times larger, by offering services to any of a score of major electronics firms. In these circumstances, there may be nothing for it but to make special grants to teachers of mathematics, creating maximum ill-feeling in staff rooms and professional associations. If anyone has a better idea of how you safeguard the national interest, they'd better produce it pretty soon.

Provided they are not simply an excuse for pure junketting, visits from overseas Members of Parliament are welcome—and can be valuable. Of one visit, there is high expectation among MPs interested in science—and for

once the visitors do not come from the United States or from those whose first interest is a European Technological Community. The Special Committee on Science Policy of the Canadian Senate will be visiting London in early September to hold discussions with responsible individuals in both the public and private sector of industry, in the government service and the universities, who play an important role in the determination or implementation of national science policy in Britain. Hearteningly, in the background blurb, we find "The Committee does not wish to meet exclusively with Government officials, but is interested, when appropriate, in meeting with representatives of successful highly technical industries to learn of their methods for research planning and evaluation, with people involved with setting up new innovative technical enterprises and people from university institutes studying matters of science policy". I hope they succeed in their objective. I have always felt that visiting foreign delegations find it hard to get to the root of how a system in Britain really ticks. This is not because their official hosts are lazy or secretive—on the contrary, government hospitality is good, and not only in the bon viveur sense—but simply because they do not meet up with many interests they ought to talk to.

One particular request from the Canadians is very much on the ball. They want to know about the means whereby governments respond to new problems or opportunities—for example, problems such as pollution and the urban and natural environment and opportunities such as those presented by developments in oceanography, nuclear power, and computers. The snappy comment is "So do we!" British MPs would like to know a little more about inter-departmental cooperation on such matters. To wit, there are 11 different Government Departments with more than a peripheral interest in oceanography.

Having stayed in Ottawa with one of Lester Pearson's senior science advisers when he was Prime Minister, I suspect that Senator Maurice Lamontagne, the chairman, and his colleagues, will have too rosy a picture of the British scene. The grass always looks greener on the other side. To be really useful to them, we must be frank about our failures, warts and all—and, by no means neglect our real successes, by keeping them *sotto voce*.

This week's hot potato

A number of MPs are becoming a little apprehensive about the effect in their West Coast constituencies of the test flight of *Concorde*. Is my parish-pump to be used as a guinea pig? I have an idea. Why not arrange it so that the tests for supersonic bangs are arranged to coincide with polling day in the Glasgow Gorbals by-election? After all, it would be no more of a boob than the occasion when the government Chief Whip inadvertently selected polling-day at the Meriden by-election to coincide with the closure of the main colliery in the constituency!

BOOKS

How science is done

by Dr Martin Sherwood

Induction and Intuition in Scientific Thought

by P. B. Medawar

Methuen, 62pp., 16s and 9s

When the Russian physiologist Ivan Pavlov first met his biographer Babkin, he asked him what he wanted to do with his life. Babkin replied that he hoped to study the history of medicine, at which Pavlov flew into a temper and asked why anyone should want to study such rubbish. For Pavlov, science was something to do, not something to philosophize about.

It is an attitude not uncommon among scientists and, in the preface to this book, based on three lectures delivered to the American Philosophical Society, Medawar says "These Lectures began in my mind in the form of a question: why are most scientists completely indifferent to — even contemptuous of — scientific methodology?" His answer was "because what passes for scientific methodology is a misrepresentation of what scientists do or ought to do". This book attempts to set the record straight and it certainly provides an interesting—and entertaining—evening's reading. But it is difficult to believe it will make even one scientist less indifferent to methodology.

Dr Martin Sherwood is senior assistant editor at the Royal Institute of Chemistry

There is something wrong in the premise that scientists are indifferent to methodology. They may be consciously indifferent to "what passes for scientific methodology" but, in reality, they are no more indifferent to methodology than a writer is indifferent to language.

The scientist uses methodology and the writer uses language; this does not require that they analyse them in philosophical terms. Just as a child comprehends the structure of language as it learns to use it, and long before it is taught "rules of grammar", so the scientist comprehends his methodology without necessarily understanding it in conscious terms.

As Medawar himself points out: "Most scientists receive no tuition in scientific method, but those who have been instructed perform no better as scientists than those who have not. Of what other branch of learning can it be said that it gives its proficient no advantage; that it need not be taught or, if taught, need not be learned?" Yet, he argues, there are three reasons for establishing what scientific methodology really is. These are validation, the understanding of hierarchical structures in Nature, and causality; "the existence of problems of this kind is justification enough for the existence of a science or area of discourse known as scientific methodology, even if its task falls short of expounding the nature of scientific method as a whole." This argument, one imagines, went down well with the Ameri-

can Philosophical Society but, with due respect, I cannot think of one indifferent or contemptuous scientist being enthused by it into a sudden interest in the subject. Yet the answer Medawar gave to his initial question implied that if scientific methodology were not a misrepresentation, scientists would disdain it less. Regardless of whether methodology is misrepresented or not in the subsequent pages, in his first chapter he seems to me to have failed to produce any convincing reason why the scientist as scientist should make a conscious effort to master the subject.

For those, and there ought to be many, who are interested not because they are practising scientists but because they would like to have some idea about the way science ("the most successful enterprise human beings have ever engaged upon") is done, the second and third chapters provide a humorous and devastating critique of Baconian inductivism, and an introduction to the hypothetico-deductive view. It is obviously greatly to Medawar's credit that, after reading him, one finds it nearly impossible to believe that anyone could ever really have thought that scientists worked on Baconian principles. (Yet there is at least one non-science professor in this country who, when his students study Bacon, points out that "scientists still think like that".)

The author is equally good at persuading one of the plausibility of the hypothetico-deductive scheme he puts forward; but we are all children of our age, and any theory nowadays that involves feedback is bound to have some emotive appeal. Although one may assent to the hypothetico-deductive view now, one wonders how long it will last in its present form. Perhaps if it has to be modified it will be to the good, for it may then show similarities to Medawar's closing description of science: "It begins as a story about a Possible World—a story which we invent and criticize and modify as we go along, so that it ends by being, as nearly as we can make it, a story about real life."

Man Modified: An Exploration of the Man Machine Relationship

by David Fishlock

Jonathan Cape, 215pp., 38s

The book is sub-titled "an exploration of the Man-machine relationship", and this it is, from almost every angle. It is a timely work, because the complexities, problems and implications of this relationship are growing exponentially and it is becoming too easy—perhaps fatally easy—to lose sight of the wood for trees. Some of the "trees" are here dealt with in detail; Man-computer, Man-motor car, Man-prosthesis, but the author is careful to remind us frequently of the "wood", the relationship between Man and the ever more complicated extensions of himself which he creates.

Some of the problems have been known for a long time. Samuel Butler said, in *Erewhon* (1872), "There is no security against the ultimate development of mechanical consciousness, in the fact of machines possessing little consciousness now . . . what will they not in the end become? Is it not safer to nip the

mischievous in the bud and to forbid them further progress?" Other problems, including what Fishlock calls "the uneasy symbiosis" between Man and his synthetic organs (cardiac pacemakers, kidney machines, myoelectric hands), have scarcely been explored at all.

The range of the subject is enormous and the scope for speculation unbounded. Astronomers believe now that there are countless stars with habitable planets, and it is possible that intelligent communities exist far more highly evolved than we. It is also possible that whenever biological life reaches the intellectual level at which the physiological organism can understand itself (ie, the stage which Man has just attained), then inorganic components are used for the replacement of defective or worn-out biological ones. In fact, the Cyborg (which is the name recently coined for animal-machine integrations) is possibly the ultimate form for any race.

The author warns that the subject is fraught with psychological, social and ethical problems, some of which he ably discusses. But there is no mention of other not improbable eventualities:

the long-term possibility of machines governing Man, the use of bodyless human brains for information storage, the development of "aversion therapy" to the stage foreseen in George Orwell's 1984. Nevertheless it is a merit that the book raises more questions than it answers and is therefore thought-provoking. For example, what is the sporting status of competitors who shun drugs but who fail to declare that they possess one or more artificial limbs or organs of superhuman functional capacity?

There are six chapters: Man Measured, Man Amplified, Man Augmented, Man Mimicked, Man Transplanted, Man Modified. Facts, figures and case histories are given in bewildering profusion. Bewildering, because without an index it is difficult to re-trace one's steps and to cross correlate data. The absence of an index is the one major blemish on this outstanding work.

Whilst this book should be of interest to all socially responsible people, whether scientists or not, it is almost essential reading for those in or about the Life Sciences, particularly the

bio-physicists and bio-engineers who (like some clinicians mentioned in the text) are occupationally at risk of allowing technical expertise to come before human compassion and social conscience. The author is to be congratulated both on the skill with which he has collated so much information from diverse disciplines and on the lively way in which he has presented much which could be starkly macabre or tediously technical.

C. Maxwell Cade

Nuclear Power

by W. G. Jensen

Foulis and Co., 176 pp., 56s

No one watches the nuclear power programme more closely than the National Coal Board. The Board's economists are waging a continual battle with the atomic energy camp, each side calculating the costs of its favoured fuel to

tenths of a penny and showing that, really, this one generates the cheaper electricity.

This book is written by a member of the NCB staff and so we can expect him to tell the story of nuclear power with less than a glowing ardour, and to give a fair amount of weight to the arguments put forward on behalf of coal, and this is the case. Dr Jensen's account is not, as one might infer from the title, a description of nuclear power technology. There is little technology in it. Rather, it is about fuel policy, mainly in Britain, the Common Market, and the United States, and especially about the nuclear threat to the coal industry. Indeed, it might have been subtitled: the threat to coal.

Starting with the post-war energy shortages in the US and Europe, he traces the various forecasts and programmes of nuclear power in its competition with other forms of fuel in the industrial world since then, and has a brief look at the future prospects.

Part of his final chapter is a rehearsal of the NCB's arguments against the British nuclear power programme—that nuclear plants are unlikely to be competitive, up to 1975 at least, with new conventional, and especially coal-fired, plants. To support this argument he cites (the report of the Brookings Institution on Britain's economic prospects, which concluded that "coal output should probably be cut back more slowly than is planned and the investment program for electricity (especially nuclear generation) should be reduced. . . .")

This is not to say that he is against nuclear power in the long run. Right at the beginning of the book he writes: ". . . only the successful development of atomic power can satisfy mankind's soaring demands for energy. . . ." The question is, how quickly should it be developed. Dr Jensen argues that the nuclear programme is running away with us.

David Hamilton

FOR STUDENT AND SPECIALIST

Principles of Dispersal in Higher Plants

by L. van der Pijl

Springer-Verlag, 153pp., \$9

Since Darwin's *Origin*, the adaptations (supposed or real) of seeds and fruits for dispersal have often formed a first object-lesson in natural history or botanical courses, demonstrating the functional significance of form and the diversity of adaptive response to a common function.

The coincidence of an autumnal start to the educational year and the location of the majority of the world's botanists, past and present, in the North-Temperate zone has tended to confine such studies to northern floras. Evidence of the appalling restriction so imposed on botanists was provided almost 40 years ago by the publication of Ridley's encyclopaedic *Dispersal of Plants throughout the World* which detailed the richness and unexpectedness (to a temperate-zone botanist) of the dispersal mechanisms of the world's and, especially, tropical flora. Discriminating botanists have kept Ridley at hand to be dipped into whenever they have felt unduly smug over the progress of plant science, or needed to sharpen their understanding and ingenuity on the evolutionary and functional problems posed by problems of dispersal: but it has not been easy to lead students into this wonderland. Emeritus Professor van der Pijl's short book will now enable them to do so.

It complements and continues the themes of the earlier *Principles of Pollination Ecology* (Faegri and van der Pijl). It includes ten sections of unequal length. A general introduction (I) leads to a short appraisal of the present, unsatisfactory terminology of seeds and fruits (II). Some of the difficulties arise from inadequate knowledge of their relationships to the flowers which precede them. Others are due to interpretations of the forms and functions of propagules without considering the, sometimes, conflicting demands of floral adaptations for

pollination (IV), or adaptations relevant to establishment of the seedling (VII)—themes brought out frequently throughout the book. Over 40 per cent of the book is devoted to accounts of the ecological dispersal classes (V) of fruits and seeds but scant attention (less than four per cent) is paid to dispersal of vegetative parts or structures. Nevertheless, the main section is generally an admirable account.

The accounts of dispersal by reptiles and ants are factually most informative; those on wind and water dispersal are perceptively critical; and this is true also of the subject of animal dispersal. Professor van der Pijl is particularly rewarding in his assessments of the significance of structural features of tropical fruits and seeds. He shows clearly how misleading interpretations can be when based on herbarium specimens or behaviour in botanic gardens rather than in the tropical field.

Equally valuable and thought-provoking is the attention given to the methods of avoiding widespread dispersal by higher plants in a variety of situations additional to semi-deserts, where the phenomenon has most frequently been studied previously. Indeed, the discussion of dispersal mechanisms in relation to communities, brief as it is, is a most stimulating section (VI) and equally so, but in a quite different way, is that of dispersal in the Leguminosae (IX). These sections are bound to lead to an assessment of the biology of dispersal in other communities and families.

Three sections, those on establishment (VII) Man and his plants (X), and on the evolution of dispersal organs (VIII) disappointed me. The first two because they were so scrappy as to be of little use, the last because it was avowedly polemical and not very illuminating. Such large areas of factual uncertainty in the morphology of tropical fruits exist that speculation seems pointless and the Durian-anti-Durian polemic is more like a mediaeval disputation than scientific comparative morphology and biology.

I have two criticisms, one of which could be easily avoided in the next edition. For the high price charged, Springer's could surely have had the text edited for normal English usage and so avoided words like basical (basal), simplistic (too simple) or distantiation (distant dispersal)

or phrases like, "In the chapter on weeds we shall find an equalization in dispersal with crop-plants, leading to coordination by human agency" (p.93). The second point is more difficult. Professor van der Pijl is addicted to a technical jargon to describe situations in dispersal biology but while these are, frequently, etymologically apposite, they do jar on the ear and can confuse the sense. Thus "hygrochasy" for wetting, "atelechory" for dispersal-avoidance, "barochory" for dispersal as a consequence of weight, or "meteoranemochores" for wind-blown propagules do not slip easily from the tongue and seem to add little to understanding, especially when combined in sentences. Nevertheless, the struggle is well worth while and van der Pijl's book is an excellent prolegomena to the problems and wonders of the dispersal of seeds and fruits.

John H. Burnett

Solid Phase Peptide Synthesis

by John M. Stewart and Janis D. Young

W. H. Freeman, 103 pp., 48s

The "solid phase" method, introduced by Merrifield in 1963, represented an entirely new approach to peptide synthesis. It uses esters derived from chloromethyl-polystyrene for carbonyl protection and its essential novel feature is that, throughout the synthesis, the growing peptide chain remains attached to the polymeric ester grouping, being removed from this only at the end of the synthesis.

This procedure has two main advantages; firstly, it avoids the need for time-consuming and wasteful purification procedures at each stage ($2n + 2$ stages for a peptide containing n amino-acid residues) and, secondly, it is well suited to automation (automatic apparatus has been described and is commercially available). Its two main disadvantages both arise from the circumstances that not all the chloromethyl side-chains of the initial polymer and not all the terminal amino-groups of the growing peptide chain are equally reactive. To overcome this as far as possible a large excess of each new amino-acid added to the growing chain has to be used; in theory this is recoverable but in fact it represents a considerable

waste of material. More seriously, the final product is not homogeneous but contains lower peptides in which one or more amino-acid units are missing; this may result in formidable purification problems, particularly with really large peptides. The method already has some triumphs to its credit, e.g. the rapid synthesis of the A and B chains of insulin and, too recently to be mentioned in the book under review, the synthesis of impure, but nevertheless enzymatically active, ribonuclease (124 residues).

Up to now anyone wishing to use the method had to rely on the necessarily condensed accounts of the experimental procedures contained in the original papers of Merrifield and others. This book changes the situation radically. Written by two workers with considerable experience in the method, it contains very full and precise details of all the experimental procedures involved, including the, often difficult, purification of the end-product.

The book is clearly and precisely written and any competent organic chemist ought to be able to carry out the operations described. This is not to say that "do it yourself" peptide synthesis is now free for all to undertake. Expertise is still needed and, as the authors say in their postscript, "the solid phase method is not black magic and does not automatically guarantee a successful outcome for every synthesis attempted". Nevertheless, properly applied and controlled, the method is clearly destined to play an ever-increasing part in peptide and protein chemistry. The present book cannot fail to make a major contribution to this development. It should be in every chemical library and on the shelves of every organic chemist and biochemist interested in peptides. It is a pity that the price is so high for so short, albeit so useful, a book.

Norman Rydon

Crystals and their Structures

by Arthur P. Cracknell

Pergamon Press, 231 pp., 45s and 35s

In recent years the growing interest in the crystalline state has brought together a range of disciplines from zoology through chemistry and physics to mathematics. The science of crystallography has been used in studies of insect muscle, protein structure, synthetic chemistry, micro-miniature circuitry and many others. Particularly through solid-state electronics it has caught the imagination of the young, and it is not surprising to see a book devoted to crystallography, aimed at the brighter science sixth former.

In this aim Dr Cracknell has set himself a very difficult task. He has to be lucid and entertaining without being "popular", and he has to describe complex phenomena with the minimum of background information.

The sections on crystal symmetry, Bravais lattices, spacegroups, colour symmetry, are fairly easy to follow. The problems and exercises set are intelligently devised and reasonably informative, although I regret that here and elsewhere in the book it was thought unnecessary to provide solutions or hints in the more difficult cases. In other parts of the book, for example the chapters on crystalline forces and crystal structures, it is doubtful whether

the intended reader will be able to gain anything more than a very superficial understanding of the content matter. This I suspect may be a consequence of the problem the author has set himself rather than any defect in the author's writing. It is regrettable that in the section on diffraction methods the author is simply misleading. The descriptions of crystal structures and ionic solids are also inadequate. Close-packing of spheres is described in the section on metals and it should have been applied to the ionic solids after the fashion of A. F. Wells. At least the sixth former could then have built up models simply from ping-pong balls and marbles rather than by the expensive and difficult ball-and-spoke method suggested in the appendix and at the same time gained some idea of the relative sizes of atoms or ions.

I believe the book will have its value and its place in the sixth form library in the physics section rather than the chemistry section.

C. K. Prout

Lectures on the Calculus of Variations and Optimal Control Theory

by L. C. Young

W. B. Saunders, 331pp., 127s 6d

As the foreword to this book mentions, the calculus of variations is a subject with a long history, and one in which a great deal of interest has recently been rekindled. Professor Young's work in this field is considerable and distinguished. In *Lectures on the Calculus of Variations and Optimal Control Theory* he devotes the first two-thirds of his book to the classical theory, and the remainder to one of the most important modern applications.

Despite the author's assertion that the lectures have been written for readers with only a minimum of mathematical preparation, a heavy dependence on functional analysis is apparent, and the book is clearly suitable only for those postgraduate students with a considerable experience of sophisticated analytical techniques. The emphasis on Hamiltonians, in the elementary theory and in the Large, and their relation to convexity theory is an excellent feature, as is the formulation of the control problem; and there is much elegance in the presentation of both this and the classical theory. It is, however, curious to find no mention of the classical isoperimetrical problem (save for a reference to Dido's problem), and no discussion of stationary values of functions of several variables, together with associated eigen-value theory.

Some readers may well be irritated by the racy style adopted with its asides and analogies. Some of these are of questionable taste and relevance such as, "The reader must not expect short solutions to problems not specially dished up for examination purposes". And is it necessary to emphasize so insistently the errors of the great mathematicians? eg, "Lagrange made many mistakes" and, à propos the multiplier rule, "... even Lagrange's rather simple-minded contemporaries had doubts about it".

Nevertheless this is an interesting and noteworthy addition to the literature, and intending specialists will find much to stimulate them.

John Clegg

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PEOPLE

Future man

The senate of the Max Planck Society has decided to add to its impressive list of research institutes and has approved the setting up of what is essentially a Max Planck Institute for Futures. The first director is to be the physicist and philosopher Professor Carl Friedrich von Weizsäcker, who has been urging the necessity for such an institute for some years now. As he puts it: "None of us knows where the rising population figures; the increasing leisure in industrial societies; the progressive transformation of the natural landscape via the use, exploitation and contamination of natural resources; and the possible development of new types of weapons based on new scientific knowledge will lead. An attempt to comprehend these consequences, however, is of absolutely vital importance for our future."

He sees a two-fold comprehension problem, which in some respects gives the impression of threatening chaos. On one hand, it is scarcely possible to predict the practical effects of present, let alone future, scientific knowledge. Of the more fundamental causes of the "chaos"—the inter-relationships within science itself, whose growth and effects we are attempting to comprehend, are themselves already becoming more and more incomprehensible simply because of the enormous quantitative growth. It will be the task of the new institute to make use of all the methods at present available in an attempt to penetrate this apparent chaos intellectually.

Professor von Weizsäcker has been engaged in work of this kind for many years now and has found that in the last resort there is no alternative to seeking out the best brains in the various fields, finding out in conversation their most important problems, confronting them with the main problems from other fields, and then attempting to bring out the relevant points of view of the various disciplines into a comprehensible form. It is now the intention to institutionalize this kind of inter-disciplinary cooperation by replacing the *ad hoc* conversation, which places too many demands on the individual, with a systematic plan of operations.

As examples of possible fields of study, Weizsäcker mentions the feeding of the world's population, structure problems in highly industrialized societies, technological prognosis, the long-term effects of biology and medicine, the development of weapon systems and the resulting strategy concepts with special regard to armament restrictions, the aims of world politics, possible political and economic structures in the European sphere of influence, and many more. On the basis of this list, he stresses that it is no use merely adding to the mass of accumulated knowledge in one or other of these fields—it is far more a case of bringing them into some sort of relationship. This inter-disciplinary study should, above all, induce the individual researchers to pose the question: "What can I most usefully study?"

Professor von Weizsäcker has now asked to be released from his teaching responsibilities at the University of Hamburg in order to take over the planning of the new institute. Initially it will have about 15 researchers, made up of people who have already worked with him or whom he particularly wants. According to von Weizsäcker, a first phase lasting several years will be necessary for the institute to develop its own working plan. During this phase the investigation of particular problems in project form will not be carried out—the entire effort will be concentrated on working out an initial background picture of how the problems likely to be encountered inter-relate. It is only from such a basic picture that the planning of the subsequently necessary investigations can emerge.

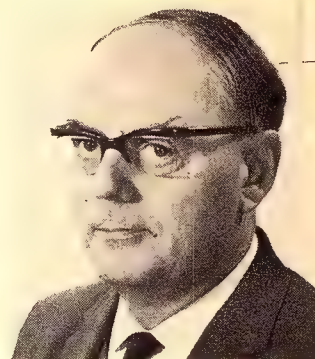
At Weizsäcker's request, the new institute will, in all probability, be set up in Munich, but as yet the financing has not been fully guaranteed. The federal government has approved the new foundation in principle and the approval of the Lander is expected shortly.

Nutritionist visitor

In London on a flying visit is Dr Even Ludvig Stokstad, professor of nutrition of the university of California, Berkeley, and biochemist to the university's agricultural research station. Dr Stokstad is probably best known for his discovery of the fattening effect of antibiotics on animals. Together with other work, the discovery secured for him awards from the Chemical Society (Borden award) and the Institute of Nutrition (Mead Johnson award). The work on antibiotics fell into the period of Stokstad's 22 years of association with the Lederle Laboratories, part of the American Cyanamid Company, but his current great interest is in folic acid and in the nutrition of the developing countries.

Folic acid, present in greens and glandular meat such as liver and pancreas, is an essential vitamin for every living cell. It is normally in balance with vitamin B 12 and like it can correct the pernicious form of anaemia; but unlike it, it can produce neurological symptoms such as degeneration of the spinal cord. Professor Stokstad is at present studying this mechanism for he believes folic acid deficiency to be the commonest vitamin deficiency in the world, affecting particularly elderly people and pregnant women.

Dr Stokstad's ideas on how best to meet the protein shortage for human consumption, particularly in the poorer countries, is not likely to be popular with those who believe that the solution lies in the fermentation products of petroleum. He claims that such products are double the price of soya bean meal, of which there is plenty, and too rich in nucleic acids which the body cannot handle. He believes that petroleum is better utilized if it goes into fertilizer production and that for food the amino acid lysine would be a far better proposition. Lysine can be obtained from the fermentation of sugar at around 60 cents a pound and a pound of lysine, added to a ton of rice, can convert the rice roughly to the equivalent of milk protein. And, as Dr Stokstad points out, "there is plenty of sugar in the world and vast areas where more can be grown".



Thomas

Weapons scientist

Mr Roy Thomas has been appointed group technical executive of the Plessey Electronics Group, responsible for coordinating all research and development work at staff level. He will also take direct line responsibility for the group's two major research centres, at West Leigh and Roke Manor.

Thomas comes to Plessey from Elliott Automation, where, from 1965, he was group chief scientist, a director of Elliott Space and Weapon Automation Ltd, and EA Radar Systems Ltd, and chairman of Elliott Electronic Tubes Ltd. A leading scientist in the guidance and control of weapons and space vehicles, he has been associated with the development of a number of well-known projects. At the Royal Aircraft Establishment, Farnborough, where he served from 1939 to 1952, he pioneered the development of analogue computing techniques for simulation purposes, culminating in the design of the Tridac simulator, a large machine for three-dimensional simulation of a missile engagement of an aircraft target. At Elliotts, after heading a research team investigating the fundamental factors governing the performance of homing guidance of missiles, he was responsible for many major projects, including the attitude control system for the Skylark high-altitude rocket, the inertial guidance system for the Europa 2 launcher, and the field artillery control system Face.

Latterly Thomas has coordinated the activities of the six research laboratories of Elliott Automation concerned with advance techniques in computers, aviation electronics, radar, opto-electronics, microcircuits, and space. He plays an important role in the dialogue between industry and government. A fellow of the Institution of Electrical Engineers and an associate fellow of the Royal Aeronautical Society, he is a past chairman and member of the National Industrial Space Committee, and is at present a member of the technical board of the Society of British Aerospace Companies, the joint research committee of the SBAC and the Ministry of Technology, the electrical Research Council, and the astronautics committee of the Aeronautical Research Council. Besides all that, he is the UK representative on the organizing executive committee of Eurosat. He is currently chairman of the joint avionics research committee of the SBAC and the Electronic Engineering Association, and of the SBAC technical executive committee for guided weapons, space and electronics.

Swiss land-planner

The International Union for Conservation of Nature and Natural Resources has appointed Mr Alfred Hoffman to the newly established post of executive officer for the Commission on Landscape Planning at the Union's headquarters in Morges, Switzerland. The new post reflects the Union's concern with the relations of man and his environment. IUCN's Commission on Landscape Planning was established in 1966, although the function for some time had been handled by the Commission on Ecology. Its programme is designed to further environmental quality, in particular to foster the concept of landscape planning as a creative approach to many problems of conservation.

Immediately prior to coming to Morges, Mr Hoffman was on the staff of the Greater London Council Parks Department in Great Britain. Before that, he was with Sylvia Crowe and Associates in London. Earlier assignments were with the city of Basle, and the landplanning and architectural firms of J. C. Warnecke in San Francisco, California; Charles Middleleer in New York City; and Robert Matthew, Johnson Marshall and Partners, in Welwyn Garden City.

Mr Hoffman, a native of Basle, is a graduate of the Agricultural College, Marcellin (Vaud), Switzerland, and the Landscape College of Weilenstephan, Germany.

IUCN is one of the world's oldest international conservation organizations. Its Commissions operate in the fields of species survival, ecology, education, legislation, national parks, and landscape planning. Twenty-eight nations are members, as are more than 200 governmental, private and international organizations from some 70 countries.

Forestry researcher

A plant pathologist with research experience in agriculture and horticulture has been appointed director of the newly established Institute of Forestry Research. The new institute, which is sponsored by the Natural Environment Research Council, is to be situated at the Edinburgh University Centre of Rural Economy at Bush.

Dr Last is a botany graduate of Imperial College, London University, and was awarded his PhD in 1951 for his studies on the relationships between primary and secondary fungal invaders of lettuce. On moving to Rothamsted Experimental Station, his research interest centred on the study of the saprophytic and parasitic micro-organisms associated with crop plants and he was the first to demonstrate the damaging effects of powdery mildews on cereals. Also he was first to draw attention to the diverse saprophytic microflora that live on the surface of living leaves, so introducing the phyllosphere concept.

While at Rothamsted he was seconded to the Sudan government for experimental work on *Xanthomonas malvacearum* attacking cotton and supervised quarantine measures in the development of the Gezira project.

In 1961, Dr Last was appointed head of the department of mycology and bacteriology at the Glasshouse Crops Research Institute, Littlehampton, Sussex, and established a strong

department studying a range of micro-organisms which influence growth and productive potential of glasshouse crops (including mushrooms). He was awarded a Dsc by the University of London in 1965.

Besides plant pathology, his interests are varied and he undertakes many extra-mural activities. His pastime activities are shared between orchid hunting, croquet and golf. A former honorary general secretary of the Association of Applied Biologists, Dr Last currently holds the office of treasurer.

At present, Dr Last is in the USA as a visiting professor in the department of plant pathology, Pennsylvania State University, shortly to return to direct Forestry's first research institute in the UK.

Two-frontier geologist

Dr Harry Hess, chairman of the Space Science Board of the US National Academy of Sciences, who died suddenly in Woods Hole, Massachusetts, last week, where he was chairing a conference on the objectives of lunar exploration, had research interests ranging from space exploration to the Earth's interior. It was this latter interest which led him in 1960 to make the then-radical proposal that a spreading of the ocean floor caused by volcanic activity along mid-oceanic ridges might serve as a mechanism to account for the theory of continental drift. Since then Princeton University, where Hess was professor of geology and curator of mineralogy, has become a world centre in this field of research.

Hess was also a founder member of the Mohole project to drill deep holes in the ocean floor as a way of exploring the Earth's crust. His interest in ocean studies goes back to the start of his career when, shortly after graduating, he became an officer in the US Naval Reserve in order to carry out measurements of the Earth's gravity field aboard submarines. As a result of this work Hess published the first bathymetric chart of the Caribbean.

While serving with the US Navy during the Second World War Hess devised a system of estimating the daily positions of German submarines in the Atlantic. He also managed, while on sea duty, to take some 250 000 miles of soundings in the Pacific; he discovered flat-topped sea-mounts or submerged islands, 3000ft to 6000ft beneath the surface and named them "guyots" in honour of Princeton's first professor of geology, Arnold Guyot.

Engineering aid

Mr F. H. Woodrow has been appointed to the newly created post of engineering adviser to the Ministry of Overseas Development. He was formerly the Ministry's adviser on engineering appointments and training—a position he assumed in 1963, when the Ministry was the Department of technical Co-operation.

Prior to the formation of the Ministry, British aid was administered by the Commonwealth Office, the Colonial Office, and the Foreign Office, but now all expenditure—currently around £200 million a year—is handled by the Ministry. Including loans, gifts and payments for British staff working over-

seas, most of it is now tied to British goods and services, so that unless a recipient country wants to employ its own people and facilities, British ones have to be called in.

In his new post, Woodrow is asked to examine projects from overseas and judge whether or not they are sound. "They come to me for an assessment, and suggestions as to how the projects might be carried out." They involve "engineering in the widest possible sense", spanning everything from harbour works, road building (including bridges), and water supplies, to earthmoving equipment and electrical apparatus for power stations. The function was previously carried out by the engineer-in-chief and his staff at the Crown Agents, but is now more appropriately performed within the Ministry.

Before joining the Ministry Woodrow saw extensive service overseas. Indeed, he was only two years out of Nottingham University—where he read civil engineering—when he left the Southampton docks engineer's department and joined the public works department in Nigeria. Having worked in Nigeria from 1929 to 1951, he moved to Tanganyika in 1951 as deputy director of public works, becoming director three years later. He stayed on, latterly as permanent secretary at the Ministry of Urban Local Government and works, until returning to England. "The whole of my experience has been in tropical countries," he says; and although dealing with all kinds of projects, from roads to airfields, he found time for two favourite pastimes—cricket and hockey. While in Tanganyika he helped get both sports properly organized, and served for some years as president of the Olympic committee. Professionally, he is a past-president of the East African Institution of Engineers and a member of the council of the Institution of Civil Engineers.

Eurochemic's new manager

Yves Leclercq-Aubreton, director of administration in the Eurochemic fuel reprocessing company, last week became managing director of the company in succession to Dr Rudolf Rometsch, who has been appointed Inspector-General of the International Atomic Energy Agency. M. Leclercq-Aubreton, an engineer (Ingenieur de l'Ecole Navale) and a former naval officer, is 49. Following his naval career, in 1957 he joined the French Commissariat à l'Energie Atomique. In April 1960 he was appointed director of administration at Eurochemic.

Eurochemic (the European Company for the Chemical Processing of irradiated Fuels), is one of the joint undertakings of the OECD's European Nuclear Energy Agency. Its irradiated fuel reprocessing plant at Mol, Belgium, came into service in July 1966.

Trustee's chairman

Dr J. E. Smith, director of the Marine Biological Association Laboratory, Plymouth, next month becomes chairman of trustees of the British Museum (natural History) in succession to Sir Landsborough Thomson, CB, OBE, who has been co-opted as a trustee for a further term of two years.

LETTERS

Protecting the environment

Man and machine

Letters to New Scientist are getting longer. Because of this we are unable to cover the variety of topics we should like to. Please be as brief as you can—Ed

No conservation votes

Sir,—As Brian Ford points out ("Industrial Dereliction and Britain's Beauty", 28 August, p.428) there is no overall government policy on land dereliction. Brutally put, the reason is that conservationist policies carry no votes. This is strange, because, as your editorial on ecology ("Probe", 28 August, p.411) points out, there is no lack of public interest in the subject.

What is lacking—and what our group intends to supply—is a communications and publicity system whereby the views of all interested individuals and groups can be made known to each other. This given, a unified policy, cutting across all political lines, will evolve under the developing public pressure.

We shall be calling a large meeting later this year to explain our plans for a National Environmental Centre; representatives of all bodies concerned will be invited to attend and explain their own views and intentions. Meanwhile, we will be most interested to take up any specific suggestions your readers may care to make.

George Hay

*The New Organization
c/o Environmental Consortium
First Floor
27 Nassau Street
London, W1*

Man and machine

Sir,—Rex Malik in "The Wages of Automation" (28 August, p.422) has oscillated between the *Brave New World* of technological demigods and the *Utopian Island*. In the end, as could almost be expected, his thesis of automation culminates in that "classic cliché-ridden problem, 'what is man?'" Unfortunately, the inevitability of "chaos" leaves one with grave doubts about the validity of his fundamental premise, simply because of the inherent contradiction in concepts.

It is short-sighted to see machines (particularly computers) as the lower crust of a new society (*Man and Machine*). In fact, this is precisely the point at which the magnitude of "mechanical influence" is underestimated. The machine's function, quite clearly, is not just confined to solving the basic requirements for survival; any intellectual, or for that matter even philosophic, activity is greatly dependent on the so-called "machine". If one cares to survey today the whole spectrum of human activity, any important band of it is either

directly or indirectly dependent on the function of "machine". So, in fact it is not "man and machine" but might prove to be "man *versus* machine". One hears the echoes from rather more imaginative minds that machines are the non-biological species in the ladder of evolution; if there is any truth in that, surely Mr Malik's speculation is certainly an underestimation.

It is difficult to comprehend the logical correlation between a fundamentally "welfare-state" type of situation of a more sophisticated kind and Man's service to Man as an acceptable substitute for the basis of a new social discipline. One can conceive of human beings as being engaged in quite a vast range of intellectual or social activities and their status in the society being categorized according to the importance of their work, but the necessary services, one would have thought, would be accomplished by machines.

Material preoccupation, as Mr Malik quite rightly points out, helps to cover crippling problems about us, and then he goes on to suggest that the absence of it might lead to chaos. With the increasing demand on technology for the fulfilment of modern ventures of mankind (e.g., space technology) on a really world-wide scale it is difficult to envisage a world without the compulsive burden of production (in a materialistic sense) in any near future.

The problem, it seems therefore, is somewhat different perhaps, the problem of a world where the machine plays a more dominant role with ourselves acting meagrely as operators. The only way we would be able to identify ourselves is not by being preoccupied with the "what is man?" type of question but wholly occupied with vast technological organization producing everything from spacecraft to pure undistorted knowledge. A Utopian world is certainly indicative of optimistic order as opposed to pessimistic chaos.

Bikash Sinha

*Rutherford High Energy Laboratory
Didcot*

Insulin team

Sir,—We were all happy to find, after many years, the arrangement of the atoms in zinc insulin crystals; it is perhaps not surprising that in the excitement of the discovery we should have allowed various items to go astray in your preliminary publication. ("Insulin in 3-D", by Dr Guy Dodson, 21 August, p.370).

The first is that you were accidentally sent for your cover picture a photograph of monoclinic and *not* rhombohedral insulin crystals. The two modifications are similar and both contain hexamers of insulin molecules around two zinc ions; the actual arrangement of the

molecules in the monoclinic form has not yet been found.

Secondly I was sad that you omitted the names of two of the research group responsible for the solution of the structure, Tom Blundell and M. Vijayan by omitting Guy Dodson's last paragraph. There are others, too, who play a considerable part in the progress of our work, particularly E. N. Baker, F. Borrás, and J. S. Rollett and, in the recent past, M. Adam, and S. Skeat in addition to those mentioned in the text.

When we reach the stage of a more precise publication of the insulin structure I hope to record all who took part over many years in this investigation.

*Dorothy Crowfoot Hodgkin FRS, OM
Chemical Crystallography Lab
South Parks Road
Oxford*

Our apologies to Professor Hodgkin and her colleagues for the omission of the final paragraph of Dr Dodson's article, due to pressure of space—Ed

Insect trade

Sir,—Professor D. F. Owen rightly draws attention to the growing trade in large and showy butterflies, ("Letters", 21 August, p.395) and cites his own experience with regard to West Africa. I recently returned from South-East Asia, and can inform you that the same sorry state of affairs exists in that part of the world as well.

Taiwan obtains a substantial amount of foreign exchange from the sale of exotic butterflies (quoted at \$30 million a year, in a recent report by Julian Amery: a figure which sounds impossibly high, but which was praised by the former Tory Minister as being an ingenious example of a successful cottage industry). In several parts of Malaysia, where large butterflies, such as Rajah Brooke's birdwing, were once common, it is now very hard indeed to find them. Unfortunately, though it would be possible to breed many of these species commercially, and thus not deplete the wild stock, it is easier and cheaper simply to pay villagers a small sum—about 6d or so—for as many as they can collect. Throughout the Orient, and particularly in tourist centres like Singapore, one can find case after case of spectacular moths and butterflies on sale in curio and arts and crafts shops. It is difficult to see how this trade can be controlled, but I would agree with Professor Owen's implication that we should at least try to control British firms who import them.

Nigel Sitwell

*Animals
21 & 22 Great Castle Street
London, W1*

Building costs

Sir,—On the occasion of Mies van der Rohe's death Ariadne makes her selection of three great architects. I must not quarrel with her choice, since I do not know much about architecture, but I know a little more about buildings (As a non architect surrounded by them I have to be careful).

Ariadne then goes on to speak about Rohe's quest for purity and simple lines, and his idea of a form best fitted to an age of advanced industrialism. And then she writes that "certainly such buildings can be put up more quickly and more cheaply than buildings of brick and stone".

On this point I differ. There is no general relationship between cost and material. I have the impression, that if anything, Rohe's buildings (and those of our own knights of purity) are more expensive than they need be.

Also it is not well established, that the speed of erection of steel framed buildings has to do with the material. Certainly the use of a steel frame does not automatically result in completion of projects in less time than comparable traditionally built schemes.

I enjoy Ariadne's comments and I hope she will not take my strictures amiss.

She said towards the end, that we might be seeing baroque buildings again. If she is looking for decorated stuff, what about the arches of, say, Sussex University? Incidentally there is food for thought there for her point about cost.

Robert F. Farnborough

Heriot Watt University
School of Architecture
Edinburgh, 3

Daedalus replies

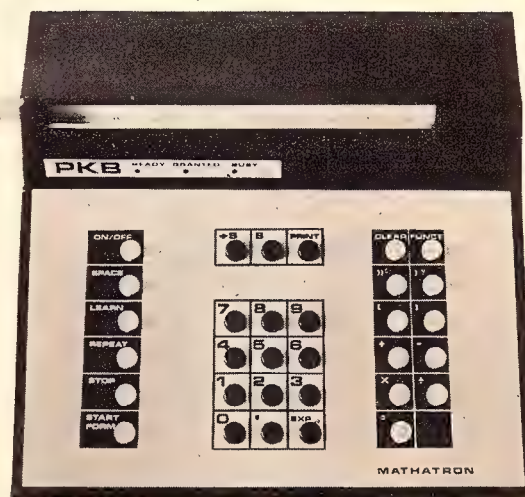
Sir,—I would like to reply to John Crabbe's letter (21 August) disputing my deductions ("Ariadne", 29 May, p.489) about "subjective bass" and its possible visual implications. My statement that the manufacturers of cheap gramophones employ it to compensate for poor bass performance derives from the McGraw-Hill *Radio Engineering Handbook* (5th Edition, 1959, edited by Keith Henney), sections 15-50 and 19-75:

"Since AC-DC sets are usually housed in small cabinets of limited acoustic properties, various suggestions have been made for improving the audio quality and in particular for improving the apparent amount of bass in the sound. One arrangement . . . is to introduce a small amount of distortion at all volume levels into the audio amplifier, there being about 5 per cent, of 3rd harmonic always present and a small amount of 5th harmonic. In this way the output-input characteristic is changed from a straight line into a slightly S-shaped curve."

S. J. Begun (vice-president and chief engineer of the Brush Development Co, and presumably in touch with commercial practice), stated in his book *Magnetic Recording* (1949):

"The ability of the ear to create different tones is sometimes used to advantage in reproducing apparatus to give what has been called 'subjective bass'. Since the reproduction of the lower bass notes is difficult . . . it is often noticeably lacking in small radios. However, by deliberately introducing a certain amount of

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distortion into the output of an audio-amplifier, thereby enhancing certain harmonics, the ear can be made to supply the fundamental at a subjectively high level."

Since Mr Crabbe's own reference to subjective bass is of 1951 vintage, it does look as if the technique was current in the 1950's and may no longer be popular. Would any audio manufacturer care to comment?

On the psychoacoustic side, it indeed appears that I emphasized an unimportant effect, misled by Mr Begun's reference to difference-tones. Nonlinearity in an amplifier necessarily creates both harmonics and intermodulation; nonlinearity in the ear will lead both to "re-instatement" of an implied fundamental and to demodulation of intermodulated frequencies. I am grateful to Mr Crabbe for pointing out that it is the first effect and not the second which dominates "subjective bass". Nonetheless my deduction, from the existence of the effect, that the ear must act as a demodulator, is unshaken: Stevens and Davis *Hearing*, (John Wiley, 5th printing 1960) quote the demodulation by the ear of a 1 kHz note modulated at 60 Hz to give a subjective 60 Hz note. The extension of the principle to nonlinearity in the retina is therefore allowable.

It is unfortunate that space-limitations prevent my friend Ariadne from detailing the technical background to my endeavours as rigorously as might be wished, but DREAD CO shareholders may rest assured that careful

analysis precedes every research project undertaken by the organization. I trust, sir, that your printing this letter will help scotch any impression, possibly abetted by Mr Crabbe's letter, that all my ideas are unsound!

Daedalus

DREADCO Research Director

Cats and milk

Sir,—In answer to the letter by Mr Elliot Slater (3 July, p.36) I must state that all my Siamese cats have the kink in the tail, and the male has the short extremely kinked tail. None of my cats is cross-eyed.

On the question of milk, I do not think sufficient distinction has been made between *fresh* cow's milk and reconstituted milk. We use here powdered full cream milk, containing lactose, and which we reconstitute. This my cats drink freely without ill-effects, although I also give them water, particularly on hot days. All the ice-cream, milk shakes, etc., so freely taken by Asian children is made with reconstituted powdered milk, *still containing lactose*, with no ill-effects. The reports of diarrhoea in Asians drinking milk have, as far as I can find out, all been concerned with fresh cow's milk. Certainly the cases in Thailand have been with milk from the new dairy cows, and I feel sure that the cases of Asians reported in Australia

are similar. The latest report from New South Wales is that Asians can become used to drinking the milk, and the ill-effects disappear with time. I find it a little difficult to understand why failure to digest lactose should cause diarrhoea—I would have thought that the lactose would have been merely passed out in normal defaecation. I can understand how some of the milk proteins and fats might cause trouble, and these are evidently denatured to a certain extent in the processing of dried milk. The fact that some Asians, unused to drinking fresh milk, are deficient in lactose, but can develop this with time, may be only a secondary effect, and not the major cause of the trouble.

(Dr) G. A. Prowse

Tropical Fish Culture Research Institute
Malacca

Man on Mars

Sir,—I agree with you ("Probe", 21 August, p.363) that now is not the moment for a manned Mars shot, but for different reasons.

Surely the point of Man in space is the eventual establishment of manned colonies across the solar system where scientists could, at first hand, carry out the long-term continuous research programmes outlined in your editorial. After all, no one thinks of carrying out the experimental research on the Antarctic continent by remote control.

Apollo 11, like Scott's Polar journey, is merely a necessary beginning to an exploration programme on a long-term basis, not just a spectacular "one-off" effort.

After man is established on the Moon and in Earth orbit, and space flight is more economic (although even today it is trivial compared with Vietnam, defence budgets, and consumer waste in the affluent societies) will be the time to send men to Mars and beyond on worthwhile missions.

Alexander W. Wishart

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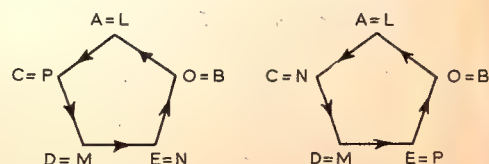
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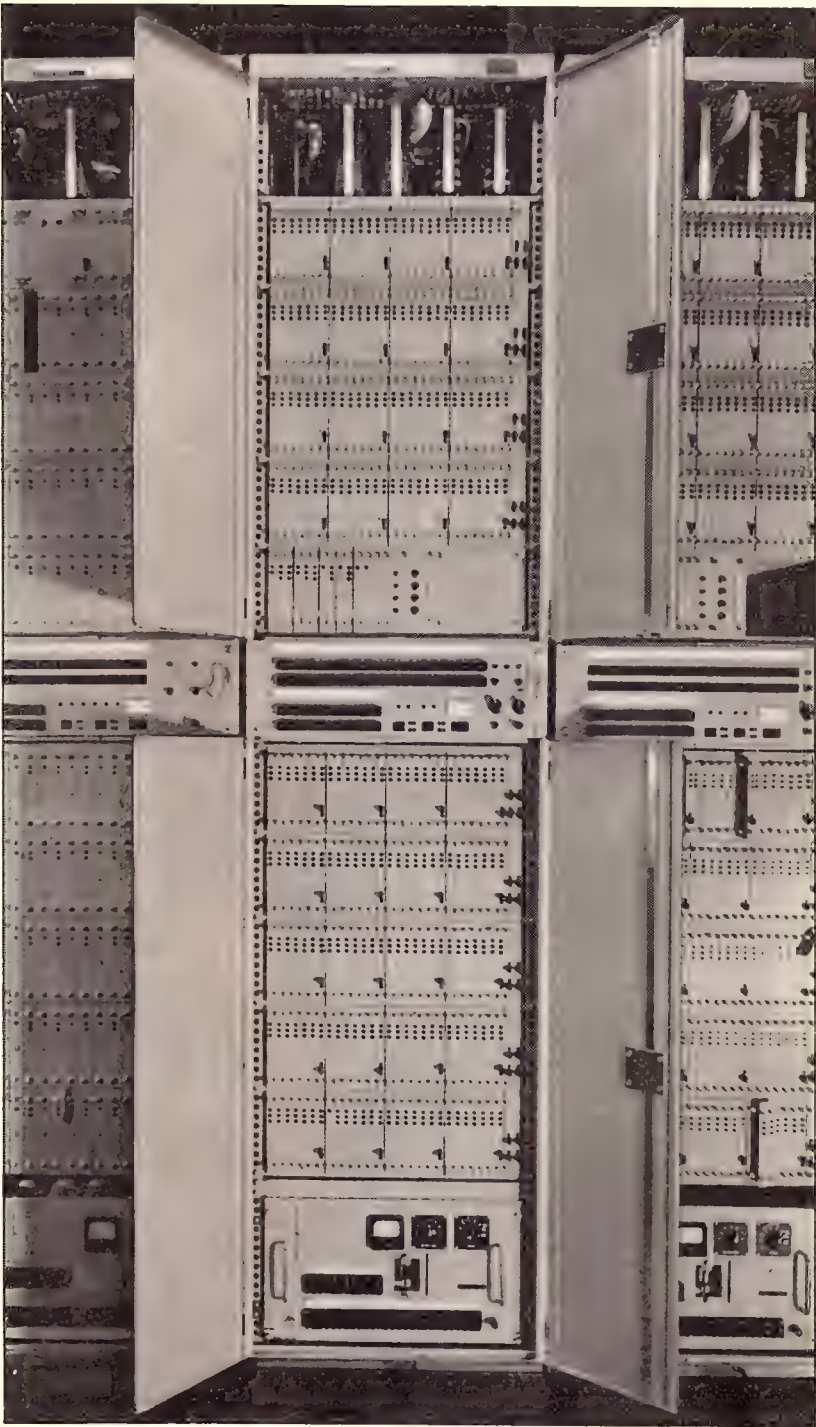
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ARIADNE

☐ Card-guessing as a way of establishing the existence (or non-existence) of extra sensory perception is a boring business and the results achieved are insignificant or downright suspect. But two reports reaching this office during the past week offer the perhaps disheartened investigator new hope. In both cases a computer was brought in to replace the cards. One of the reports, distributed by the US Atomic Energy Commission, deals with the work of Mr Helmut Schmidt, a Boeing physicist, who carried out two sets of experiments in numerical prediction (over a period of months) using a number of human subjects. The best scores were put up by an individual described only as a "professional psychic" but a truck driver also produced an "unusual score". The probability of the first man achieving his score by pure chance was computed at 1:94 000 and for the second, 1:27 500. The second report dealt with the work of Professor John Mihalasky of the Newark (New Jersey) College of Engineering. For the past seven years he has been examining the possibility of pre-cognition playing a part in successful decision-making at the higher levels of industry. The test he devised starts with the participants being given a list of five metaphors to choose from. Their choice is said to indicate their attitude towards time. (Mihalasky labels them "dynamic" or "undynamic".) Then each is asked to select randomly a 100-digit number by punching holes in computer cards. They also punch to indicate sex and their previously established personality category. The card data are fed into a computer which is programmed to select a random 100-digit number for each participant, then to compare the machine-selected number, digit by digit, with the participant's choice. The chances of a participant selecting any of the 100 digits before it exists are 1 in 10 and the average should be 10 correct guesses but Professor Mihalasky says his "dynamic" participants do better than average while the others do worse.

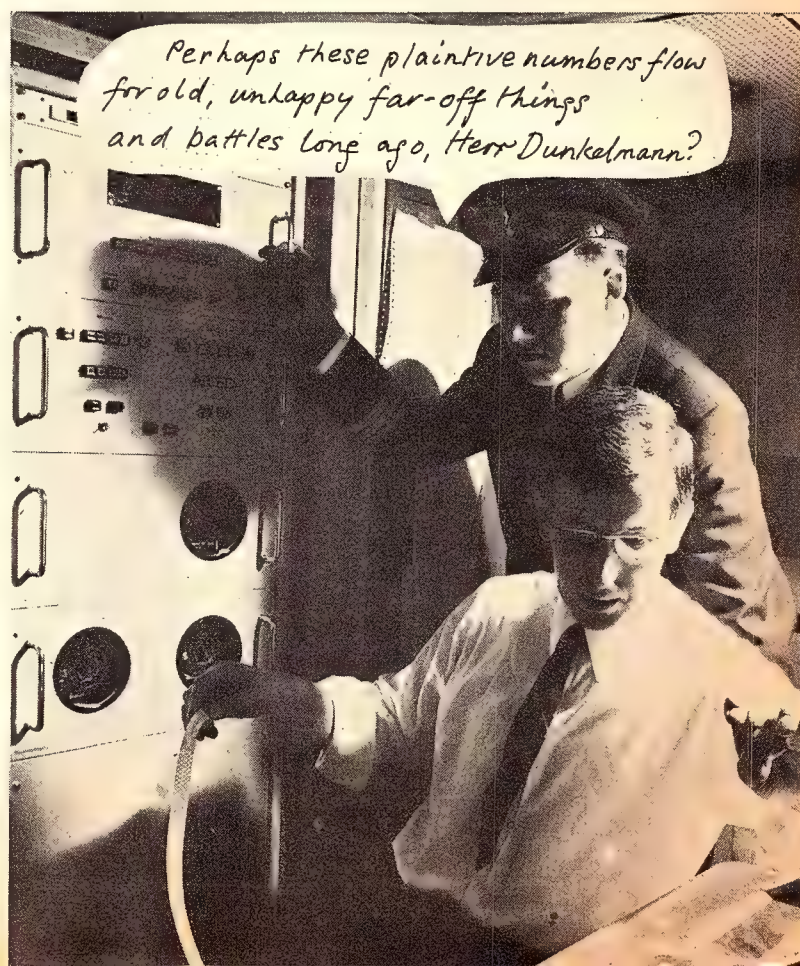
☐ Some figures put out last week by the Office of Health Economics show that while Britain lost between two and six million working days through sickness in the years 1962-66 the loss through sickness was many times greater—301 million days—in 1966-67. The OHE people suppose, quite reasonably, that people in a wealthy society are not prepared to work on through the minor illnesses their predecessors put up with. I think there is more to it than this. Today's large industrial groupings are bound to reduce the sense of individual responsibility to the point where he cannot see that his presence or absence from work makes a ha'p'orth of difference. Nor does it, in fact. It is only when large numbers of individuals are away sick that production is threatened. Figures going back to 1954 show that, although the 1967 total was slightly down on that of 1966, the trend seems

to be upwards (I like the unofficial strikes?). Surely there is a warning here for industry's managers. They must learn to think along the lines of the executives of Philips who for five years now have been experimenting with various arrangements to make work more likeable. Unions, instead of assuming that wage rises are all that matter, might put a bit more emphasis on the frequently appalling conditions in which many of their members still have to work.

☐ Masfield's "dirty British coaster" never carried anything like this even on the maddest March day. From *British Export Business* (September) published by the Board of Trade: Javelins for Canadian athletes; an STOL aircraft to carry dirty linen from the Virgin Islands to Puerto Rico where the laundries are; compressors to damp down the waves (through aeration) for water skiers at Copenhagen; refrigerated bull semen containers for Poland and Rumania; equipment to handle soya beans now stored in the old German submarine pens at Saint Nazaire; medical pipelines for a Turkish military hospital. I suppose it all helps to keep the gnome from the door.

☐ My chirathanasian friend Daedalus has been musing on the left-handedness of life—the biochemical tendency, where a molecule can exist in both "left" and "right" antisymmetric forms, to choose the left one. Vitamin C is such a molecule; its right-hand form is not a vitamin at all, but biochemically as useless as a left-hand thread bolt in a normal right-handed

engineering shop. Daedalus is exploiting this in a novel antibiotic treatment for "inverting" marauding bacteria so that they can no longer feed on normal tissues, and expire baffled by a world whose biochemistry is suddenly opposite to theirs. His scheme generalizes from the ammonia maser, which depends on the ability of the ammonia molecule to flap inside-out, umbrella-like, under suitable irradiation. Now every asymmetric molecule must have some vibration-frequency which, excited to resonance by radiation of the same frequency, will lead to inversion. Daedalus calculates that for most molecules this resonance will be somewhere in the far infrared, and he is building a big therapeutic infrared source, tunable to selectively invert some key bacterial biochemical while leaving the patient's metabolism untouched. This humane irradiation, so much pleasanter than posterior injection of penicillin, would be less likely to develop "resistance" in the bugs, as any of so many vital compounds could be chosen for inversion. But care would be needed—only slight frequency error could have the unfortunate patient on a forced diet of right-handed sugar and vitamin C, or even (if our body-form is governed by chemical information as closely as the DNA-boys claim) cause his heart to migrate to the right side of his chest! The same principle makes possible an ideal slimming aid which inverts the molecules of food, rendering it nutritively valueless while outwardly unaltered. A crafty scan with Daedalus's infrared cruet and the dedicated dieter can gorge with the best of them!



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APPOINTMENTS AND SITUATIONS VACANT

NEW ZEALAND UNIVERSITY OF CANTERBURY Christchurch

SENIOR LECTURER OR LECTURER IN PHYSICS

Applications are invited for the above-mentioned post. Applicants should have suitable qualifications and interests in solid state studies, atmospheric physics, theoretical physics or astronomy.

Applications close on the 31st October, 1969.

Salaries are under review. Existing salaries for Lecturers are \$NZ3,100×\$NZ200—\$NZ4,700, \$NZ4,800 p.a., and for Senior Lecturers \$NZ4,700×\$NZ200—\$NZ5,500 (bar) and thereafter a range to \$NZ6,600.

Particulars, including information on travel and removal allowances, study leave, housing and superannuation may be obtained from the Secretary-General, Association of Commonwealth Universities (Appts.), 36 Gordon Square, London, W.C.1.

HISTOLOGY TECHNICIAN

Assistant Experimental Officer required to participate in work on genetical aspects of pathology of laboratory animals with particular reference to neuropathology. Histological experience essential. Applicants should have a pass degree, H.N.C. or equivalent qualification. Salary scale £940 per annum at age 22, £1,208 at age 26 (Maximum starting salary) to £1,454. Voluntary contributory superannuation scheme. Applications, stating experience and giving names of two referees, by 27th September, 1969 to:—The Secretary, A.R.C. Animal Breeding Research Organisation, King's Buildings, West Mains Road, Edinburgh EH9 3JQ.

UNIVERSITY OF ABERDEEN RESEARCH ASSISTANT IN BIOCHEMISTRY

Applications are invited for the post of RESEARCH ASSISTANT for work with Dr. W. A. Hamilton on oxidative phosphorylation in bacterial membrane systems.

Salary on scale: £940×60—£1,060. Superannuation (F.S.S.U.).

Further particulars from The Secretary, The University, Aberdeen, with whom applications (2 copies) should be lodged by 17th October, 1969.

RESEARCH TECHNICIANS. Several technicians are required for interesting positions in our Chemical Research Laboratory. Preference will be given to applicants with experience or with qualifications in chemistry. Apply in writing giving details of experience and education to Dr. T. D. Binns, Dargo Technical Research Ltd., 9, Carlisle Road, Colindale, London, N.W.9.

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UNIVERSITY OF BIRMINGHAM Department of Anatomy

Technician required to assist in the design and construction of electronic apparatus for neurological research, also to participate in routine experimental procedures involving animals and man. Some knowledge of linear and digital circuit techniques required, but no previous experience in the medical sciences is necessary. Applicants should have obtained or be studying for H.N.C. or an equivalent qualification in electronic engineering or physics. Salary: £773–£1,007 p.a.

Apply: Assistant Secretary (Personnel), Personnel Office, University of Birmingham, P.O. Box 363, Birmingham 15, or telephone 021-472 1301, extension 434, quoting reference 401/T/139.

RESEARCH ASSISTANT required in Department of Cybernetics and Instrument Physics for research on the development of instruments for geophysical applications. Candidates should have a degree or equivalent in Physics or Engineering. Some experience in electronics is essential. The post will be for two years in the first instance. Salary up to £1,200 per annum. Apply in writing, quoting M.57 to Assistant Bursar (Personnel), University of Reading, Reading, Berks.

MEDICAL RESEARCH COUNCIL DEMYELINATING DISEASES UNIT

Technician required for tissue culture work in the central nervous system. Previous knowledge of this tissue not essential.

Salary and grade according to experience, age and responsibility which will be assumed.

Apply: The Director, Medical Research Council, Demyelinating Diseases Unit, Newcastle General Hospital, Westgate Road, Newcastle upon Tyne NE4 6BE.

WALSgrave HOSPITAL COVENTRY CV2 2DX

Department of Medical Physics

2 Physicists (Basic Grade) required for expanding Physics service associated with new General Hospital. Candidates should possess an appropriate Honours degree. Previous experience desirable but not essential and applications are invited from new graduates. Salary: £1,080–£1,845.

Application forms from: Hospital Secretary.

CRANFIELD

Design and Development of Advanced Hydraulic Systems

Applications are invited from Mechanical/Control Engineers with appropriate experience for appointment as RESEARCH OFFICER or SENIOR RESEARCH OFFICER in the DEPARTMENT OF ELECTRICAL AND CONTROL ENGINEERING to work on the analysis, mathematical modelling, initial design and laboratory assessment of an advanced hydraulic system of an unusual nature. Some experience of hydraulic servo-system design and development is essential, and a knowledge of analogue or digital computing will be advantageous.

The successful candidate will have adequate laboratory facilities under his control for experimental work, and access to ICL 1905 digital and AD 256 hybrid computers.

Salary in range £1,240 to £1,470 (Research Officer); £1,585 to £2,390 (Senior Research Officer), F.S.S.U. Commencing salary according to qualifications and experience.

The College has an estate of modern houses and residential facilities and consideration will be given to accommodation requirements.

Application form from Assistant Registrar, The College of Aeronautics, Cranfield, Bedford.

UNIVERSITY OF ST ANDREWS Department of Chemistry

Applications are invited for the (temporary) post of TECHNICIAN assisting with a research unit under the direction of Professor P. A. H. Wyatt. Fluorescence, laser and other techniques are involved, and the post will be for two years, with the possibility of conversion to permanency. Salary will be in the range £773–£1,077 and there is a pension scheme. Applications, with the name of a person to whom reference can be made should be sent to the Deputy Secretary, University of St Andrews, College Gate, St Andrews, Fife, before Saturday, 18th October, 1969.

JUNIOR TECHNICAL OFFICER (male) required for Division of Biophysics to assist with research into the purification and analysis of proteins. The work involves use of biochemical and some immunological techniques. Applicants will be considered, aged between 21–25, who have obtained a degree or the equivalent in Chemistry or Biochemistry. Initial salary will be on an incremental scale from £927 p.a. (at age 21) to £1,440. Good promotion prospects and excellent conditions of employment. Please apply in writing quoting our reference N.S.13/3, to: The Personnel Officer, National Institute For Medical Research, The Ridgeway, Mill Hill, N.W.7. Telephone 01-959 3666.

KENNEDY INSTITUTE OF RHEUMATOLOGY—DIVISION OF IMMUNOLOGY

Research assistant required for work on cellular immunity in experimental leishmaniasis. Initial salary in range £1,100–£1,400 p.a. Further details can be obtained from the Secretary, Kennedy Institute, Bute Gardens, London, W.6 to whom applications (naming two referees) should be sent.



ESSO RESEARCH CENTRE
HEAD OF
INFORMATION SERVICES

Applications are invited from suitably qualified people to manage the Information section at Esso Research Centre, Abingdon, Berks.

The section provides information and communication services in an organisation employing 150 graduate scientists in applied research and development work on petroleum products.

The primary function will be to manage the personnel and facilities so as to maintain and improve the service provided, and anticipate and plan for the information needs of the future in the light of advances in information techniques.

The candidate selected will have qualified professionally as an information scientist or else will have qualified in an appropriate science/technology and obtained working experience in modern information science techniques. He will also have demonstrated ability in the organisation and management of significant numbers of people.

We envisage an initial annual salary of the order of £2,800 at age 35. Salary will however be negotiable according to age and experience. We would prefer to receive applications from those suitably qualified in the age range 30-35.

Please write, summarising qualifications, experience and personal details to:

Mr. E. C. G. Jelfs (Ref: 913/F.)
Esso Research Centre, Abingdon, Berks.

AUSTRALIA

NEW SOUTH WALES

Department of Agriculture SENIOR RESEARCH OFFICER

(ANIMAL HUSBANDRY)

AGRICULTURAL RESEARCH INSTITUTE, WAGGA WAGGA

Salary: \$A6,360 range \$A6,800 per annum, with progression to \$A7,350 per annum, subject to conditions.

Qualifications: Degree in Agricultural Science, Rural Science or equivalent. Several years of post-graduate experience in animal husbandry research essential.

Duties: To formulate and supervise animal husbandry research programmes in the southern wheat belt and southern tablelands of New South Wales.

Subject to certain conditions, the successful applicant will be eligible for:—

- ★ Payment of fares to Sydney
- ★ Financial Assistance towards cost of removal expenses
- ★ Financial assistance towards cost of initial accommodation expenses

General: Single accommodation available at \$A7.20 per week.

For application form and further information write to the **Recruitment Section, New South Wales Government Offices, 56 Strand, London, W.C.2.**, where applications close on **30TH SEPTEMBER, 1969**. When writing, please quote reference 44/407 (NS).

Hon. A. Landa, *Agent General.*

MEDICAL RESEARCH COUNCIL
NATIONAL INSTITUTE
FOR MEDICAL RESEARCH

Applications are invited for the post of Head of the Engineering Department in the National Institute. The first responsibility of the Department is to provide a mechanical and electronic instrumentation service to the Institute, including computing facilities on line to other experimental equipment. Full workshop facilities and a Honeywell DDP 516 computer system are available. In deciding on scientific priorities and matters to do with establishment, the Head will be expected to consult a small Advisory Committee chosen from senior members of the Institute's scientific staff. The staff of the Department will probably not exceed four scientists and about 20 technical officers and technicians. The salary will be in the Professional range and enjoys F.S.S.U. benefits. Applications should reach the Director (from whom further details may be obtained), National Institute for Medical Research, London, N.W.7, by December 1st, 1969.

LIVELY girl, interested in science and scientists, capable of attention to details, and with competent shorthand and typing; this describes the secretary to our Science Editor. Opportunities for learning editorial work. Is this you? If so, ring Personnel Department 405-6900 for interview.

GLAXO LABORATORIES LIMITED, ULVERSTON

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SENIOR INSTRUMENT TECHNICIAN

Antibiotics such as Penicillin and Streptomycin are produced in large quantities at our modern factory close to the Lake District. The fermentation process involves complex bio-chemical reactions. It is desirable to measure the progress of many of these inside the pressurized sterile fermenters.

We are looking for a competent, practical Instrument Technician with some knowledge of chemistry, physics and electronics who could converse with our graduate research staff and convert their bright ideas into effective hardware.

The post offers a good salary, the opportunity to participate in the Company's profitability and contributory pensions and life assurance scheme.

Apply in writing to: **The Personnel Officer (DWM)**
Glaxo Laboratories Ltd.,
Ulverston, Lancs.

WEST HAM COLLEGE OF TECHNOLOGY

Department of Chemistry

RESEARCH STUDENTSHIP

Applications are invited for an S.R.C. Post-graduate award, under the Co-operative Awards in Pure Science scheme, to study mass-spectrometric techniques of sequence analysis of peptides and proteins. The project will be conducted at West Ham College of Technology, and at the Consultant Laboratory, A.E.I. Ltd., Manchester.

The maximum period for the award is three years; the successful applicant will be expected to register for a Higher Degree of the University of London, and should hold a First Class or Upper Second Class Honours Degree or an acceptable equivalent.

Further information can be obtained from Dr G.C. Barrett, West Ham College of Technology, Romford Road, London E.15, to whom candidates should apply as soon as possible with full particulars, and names of two referees.

WANTED immediately SENIOR GRADE BIOCHEMIST in the Biochemistry Department, with salary according to National Scales. The Department serves 1,000 beds, of which 600 are acute, at the District Hospital Centres at Windsor and Ascot, together with Maidenhead Hospitals, and a large volume of work is undertaken for General Practitioners. It has recently been extended and is well equipped. Opportunities exist for research. Applications to Senior Pathologist, Area Laboratory, King Edward VII Hospital, Windsor.

THE UNIVERSITY OF MANCHESTER

DEPARTMENT OF PHYSIOLOGY AND MANCHESTER ROYAL INFIRMARY DEPARTMENT OF ANAESTHETICS

Applications invited from candidates with medical qualifications registrable in this country for two joint posts of Temporary Assistant Lecturer in Physiology/Senior House Officer in Anaesthetics. The persons appointed will work in the University Department of Physiology and in the Department of Anaesthetics in the Royal Infirmary, spending approximately half their time on work in each department. Experience in Anaesthetics desirable. Salary range p.a.: £1,570-£1,790. Duties commence October 1st, 1969, or as soon as possible thereafter. Particulars and application forms (returnable by September 17th) from the Registrar, The University, Manchester, M13 9PL. Quote ref: 190(a)/69/NS.

THE UNIVERSITY OF MANCHESTER

A TECHNICIAN or JUNIOR TECHNICIAN is required for the Electron Microscope Unit of the Departments of Botany and Zoology. The successful applicant will be expected to eventually take charge of photographic work in the Unit but training will also be given in other fields. Previous experience an advantage but school leavers will be considered.

Salaries in the range:—Technician £773 at age 21 to £1,077 per annum. Junior Technician £377 per annum at age 16 to £637 per annum. Supplements are paid for approved qualifications.

Applications, giving full details of age, qualifications, and previous experience (if any) should be sent to Dr. R. D. Butler, Electron Microscope Unit, Department of Botany, The University, Manchester M13 9PL.

LONDON BOROUGH OF HARINGEY

EDUCATION DEPARTMENT

Laboratory Assistant (Full-time). N.J.C. Technical Grade 3. Salary £1,020 to £1,185 per annum, according to experience and qualifications.

Required at Stationers' Company's School, Mayfield Road, N.8.

Applicants should have Ordinary National Certificate, or Ordinary National Diploma, City and Guilds Lab. Technicians Certificate, 4 G.C.E. Passes, with 2 'A' levels in appropriate subjects, Membership of Institute of Science Technology or an equivalent suitable qualification, or 5 years suitable experience.

Prescribed conditions. 5 day 38 hour week.

Application forms from Chief Education Officer, Somerset Road, N.17 returnable by 26th September, 1969.

WEST SUSSEX COUNTY EDUCATION COMMITTEE

LABORATORY ASSISTANT

required as soon as possible for 38 hours per week throughout the year, including School Holidays, at

KING'S MANOR COMPREHENSIVE SCHOOL Kingston Lane, Shoreham-by-Sea, Sussex.

Salary scale rising to maximum of £800 per annum (eventual maximum £831 per annum) and commencing according to previous experience. Additional remuneration payable in respect of certain specialist qualifications. Apply in writing to the Headmistress giving details of age, experience and any qualifications, together with names and addresses of two referees.

GRADUATE, young,

required for library and technical information. Must have degree in a Science subject and an interest in abstracting and classifying literature. Please write for application form to The Secretary, Biorex Laboratories Ltd., Biorex House, Canonbury Villas, London N.1.

SCIENTIFIC CIVIL SERVICE

AIR TRAFFIC CONTROL EVALUATION UNIT

Bournemouth (Hurn) Airport

EVALUATION OFFICER (graded Experimental Officer) required for duty with the Air Traffic Control Evaluation Unit. The Unit is engaged in the investigation, by simulation methods, of all aspects of Air Traffic Control—including airways, airports, centres, data handling—in both real-time and fast-time. Using computers, a programme of Exercises is run, and data analysed. The officer appointed will be responsible for advising on facilities and equipment required, operating computer programmes (proposing changes if necessary), the control of a number of staff, and maintaining the flow of data for the Exercise. The library of programmes, mainly written by specialists, is expanding and it is desirable that the officer is capable of writing programmes and contributing to the mathematical/statistical techniques of analysis. An understanding of the strict discipline of method, efficiency and accuracy in the handling of large quantities of data is essential, whilst a background knowledge of statistics, operational research and aviation would be an advantage.

Qualifications (see below) should be in mathematics. Some background of statistics, operational research, computers or aviation desirable.

Prospects of permanent pensionable appointment.

The officer appointed will be on loan to the Board of Trade.

APPLICATION FORMS from the Ministry of Technology, SME 1, Room 415, Savoy Hill House, Strand, London, W.C.2.

Please quote HC/2D/1834/F. Closing date: 26th September, 1969.

ROYAL RADAR ESTABLISHMENT

Ministry of Technology, Malvern, Worcs.

CHEMISTS/PHYSICISTS/METALLURGISTS (graded Experimental Officer/Assistant Experimental Officer) required to work on the crystal growth and assessment of the highest quality electronic materials, e.g. elemental and compound semi-conductors, laser and electro-optic materials. An initial period of training in crystal growth and related subjects will be given. In addition to the basic qualifications for the grade (see below) experience in applied chemistry, physics or metallurgy is an advantage, and experimental experience in crystal growth techniques also desirable but not essential.

Prospects of permanent pensionable appointments.

APPLICATION FORMS from the Director at the above address.

Please quote: HC/2D/1852/F. Closing date 30th September, 1969.

STORES AND CLOTHING RESEARCH AND DEVELOPMENT ESTABLISHMENT

Colchester, Essex.

Two posts for TEXTILE TECHNOLOGISTS (graded Experimental Officer/Assistant Experimental Officer) with a broad general knowledge of textiles processes and specialised knowledge of and industrial experience in one or more of the following: Clothing Development; Coated Fabrics and Expanded Products; Textile Finishing; Newer Methods of Fabric Manufacture and Knitwear.

Prospects of permanent pensionable appointments.

APPLICATION FORMS from Ministry of Defence, CE2(f)AD, Northumberland House, Northumberland Avenue, London, W.C.2. Please quote 124/68/F.

SALARIES, QUALIFICATIONS AND AGE LIMITS

EXPERIMENTAL OFFICER CLASS

A qualification of the standard of HNC or a general degree in an appropriate subject is normally required, but if you are under 22 and have appropriate "A" levels, you will also be considered. Starting salaries depend on age and experience in the range £683-£2,006.

Promotion prospects:

Age: normally 26-30 for E.O. 18-27 A.E.O.



A free booklet entitled "THE SCIENTIFIC CIVIL SERVICE" is available on request from Civil Service Commission, Savile Row, London, W1X 2AA.

THE UNIVERSITY OF SHEFFIELD

DEPARTMENT OF APPLIED MATHEMATICS AND COMPUTING SCIENCE

Applications are invited for a post of LECTURER in COMPUTING SCIENCE, duties to begin as soon as possible. Salary in the range £1,240-2,850 with F.S.S.U. provision. Further particulars from The Registrar, to whom applications (4 copies) should be sent by 1 October, 1969. Quote Ref. R48/H.

TECHNICIAN (a) or Senior Technician I (b) or Senior Technician II (c) required for Rheumatism Research Unit. Salary on scale (a) £935-£1,195 (b) £1,125-£1,450 (c) £1,350-£1,912. Experience in electron microscope techniques used in biology particularly section cutting and day-to-day microscope maintenance. Possession of AIMLT or FIMLT is desirable (or equivalent qualifications offered by City & Guilds Institute of Institute of Science Technology). Applications with names of two referees to Director, Medical Research Council Rheumatism Unit, Canadian Red Cross Memorial Hospital, Taplow, Maidenhead.

THE UNIVERSITY OF MANCHESTER INSTITUTE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF MECHANICAL ENGINEERING

Thermodynamics and Fluid Mechanics Division. Application of On-Line Computer for Data Acquisition and Processing in Internal Combustion Engines.

EXPERIMENTAL OFFICER AND SENIOR ELECTRONICS TECHNICIAN

Applications are invited for two appointments on the above research project. One appointment will be for an Experimental Officer or Research Assistant and the other appointment will be for a Senior Technician.

The Experimental Officer will be responsible for the overall system design (software), for the supervision of the interface connections, for the organisation of data acquisition and processing and for the preparation of technical work in linking the computer to the laboratory engines. He will operate the system and advise the research group during the tests. Experience in process control computing and data acquisition is necessary. Candidates should have either a Higher National Diploma, a Higher National Certificate or a degree. Salary within the scale: £1,000-£1,660.

The Senior Technician will be responsible, under the experimental officer, for the servicing and maintenance of the whole facility. This will include the preparation and manufacture and testing of electronic circuitry and all the ancillary hardware. Experience will be required in electronic instrumentation with H.N.C. or equivalent qualification. Salary within the scale: £1,026-£1,281 (additions for approved qualifications).

Computer Assistants will be available for the programming work under the direction of the Experimental Officer.

The whole project is under the direction of Professor R. S. Benson. Requests for application form, specifying post for which application is being made, should be addressed to the Registrar, UMIST, Sackville Street, Manchester, M60 1QD. Completed forms to be returned by 30th September.

LABORATORY TECHNICIAN

to assist in protein research. Work will involve amino acid analysis, chromatographic separations and instrumental analysis. Minimum qualification A' Level chemistry or ONC. Initial salary in range £540-£1,250, depending on age and qualifications. Day release encouraged. Applications to Director, British Leather Manufacturers' Research Association, Egham, Surrey.

UNIVERSITY OF BRISTOL. Department of Zoology. Technician required for biological research project on the electron microscopic structure of invertebrate nervous systems. Commencing salary according to age, qualifications and experience. Applications, giving age, qualifications, experience to date, and the names of two referees to Professor G. M. Hughes, Department of Zoology, Woodland Road, Bristol BS8 1UG by 16th September, 1969.

CSIRO RESEARCH SCIENTIST (MOLECULAR BIOLOGY)

AUSTRALIA

DIVISION OF PLANT INDUSTRY

GENERAL The Division of Plant Industry of the Commonwealth Scientific and Industrial Research Organization, with headquarters situated in Canberra, A.C.T., comprises some 180 scientists, conducting pure and applied research in genetics, plant breeding, biochemistry, physiology, microbiology, inorganic nutrition, ecology, agricultural physics, agronomy and plant introduction. It is well equipped with instruments for the characterization of macromolecules.

The Molecular Biology Unit at present consists of three scientists. The work in progress includes the study of chromosome behaviour and replication, the evolution of enzymes and the genetic mapping of enzyme structure, molecular mechanisms of adaptation and the genetics of regulatory processes. The Unit is seeking to appoint a further member with interests in the above or related fields together with a knowledge of protein chemistry, for which the unit is very well equipped.

QUALIFICATIONS Applicants should have a Ph.D. degree in an appropriate field or postgraduate research experience of equivalent standard and duration, supported by satisfactory evidence of research ability.

SALARY Depending upon qualifications and experience, the appointment will be made within the salary range of Research Scientist, \$A5,321–\$A6,693 p.a., or Senior Research Scientist, \$A6,963–\$A8,045 p.a. In the case of an applicant having outstanding qualities of leadership in research and eminence in the broad field of study appointment at a higher salary would be considered. Salary rates for women are \$A428 p.a. less than the corresponding rates for men. Promotion within CSIRO to a higher classification is determined by merit.

CONDITIONS The duration of the appointment will be determined in consultation with the successful candidate; some applicants may prefer a fixed term appointment for three years. The appointment will be conditional upon passing a medical examination and an initial probationary period of twelve months may be specified. An indefinite appointment carries with it Commonwealth Superannuation Fund or Provident Account privileges. Fares paid for the appointee and his dependent family. Further details supplied on application.

Applications, (quoting Appointment No: 130/1029), and stating full name, place, date and year of birth, nationality, marital status, present employment, details of qualifications and experience, together with the names of not more than four persons acquainted with the applicant's academic and professional standing, should reach:—

Mr. R. F. Turnbull,
Chief Scientific Liaison Officer,
Australian Scientific Liaison Office,
64 Kingsway, LONDON, W.C.2.
by the 10th October, 1969.

Applications in U.S.A. and Canada should be sent to The Scientific Attaché, Australian Embassy, 1601 Massachusetts Ave. NW, WASHINGTON DC 20036.

TECHNICIAN required for routine work at onset but opportunity later to do all aspects of hospital blood transfusion work. Qualifications: A.I.M.L.T. or equivalent wanted for blood transfusion. Study classes on the premises for "special" examination of I.M.L.T. Salary in range up to £1,280 per annum. Applications to the Secretary, Royal Postgraduate Medical School, Hammersmith Hospital, London, W.12, quoting ref: 7/116.

EXPERIMENTAL OFFICER or Assistant Experimental Officer required for Glasshouse operations at the Horticultural Research Laboratories, Shinfield, Reading. Appropriate experience and basic university or college qualifications required. Salary £1,590–£2,006 per annum (E.O.) or £872–£1,454 per annum (A.E.O.) Applications, with two references and quoting M.61, to Assistant Bursar (Personnel), University of Reading, Reading, Berks.

SCIENCE EDITOR

required by

Heinemann Educational Books

to handle its distinguished and expanding list of new books in science, mathematics and technical subjects, from school texts to advanced monographs. In addition to excellent editorial (although not necessarily academic) qualifications, familiarity with book production is desirable.

*Applications to Hamish MacGibbon, Science Director
Heinemann Educational Books Ltd.
48 Charles Street, London W1X 8AH.*

THE UNIVERSITY OF LEEDS

INDUSTRIAL UNIT OF TRIBOLOGY

The Industrial Unit of Tribology was established in the Institute of Tribology within the Department of Mechanical Engineering on April 1st, 1968, with the support of the Ministry of Technology.

The Unit offers a consulting research and development service to industry in the field of lubrication, friction and wear.

The Unit is now well established and, in order to meet ever increasing demands from industry, further staff must be appointed to join the present small but enthusiastic team. Applications are invited for the following posts:—

1. ENGINEER

The successful candidate will be a chartered engineer and a graduate. He will have had several years experience in the field of lubrication, friction or wear.

2. INFORMATION OFFICER

The successful candidate will be a graduate with experience of information retrieval systems in a technical organisation. A contract has been placed with the Unit for critical literature surveys to be made over the whole field of tribology and the successful candidate would be expected to assist in the initiation and development of this project. An ability to scan journals in one or two foreign languages would be an asset.

3. HOFFMANN RESEARCH FELLOW

A large and important contract has been placed with the Unit by the Hoffmann Manufacturing Company Ltd., for the development of gas bearing technology. A graduate is required to join a small team to work in this expanding field which is largely concerned with problems associated with silicon nitride and gas bearings operating at high temperatures.

4. DESIGN ENGINEER

The Industrial Unit undertakes the design and erection of experimental equipment for the purpose of testing materials, lubricants, bearings and other mechanical systems.

The successful candidate will have a wide experience of work in this or similar fields, and will be capable of undertaking the design and supervision of the erection of test machinery.

The conditions of employment for these posts will be similar to those relating to academic staff and further particulars can be obtained from the Registrar and Secretary.

Successful candidates will be engaged at an appropriate point on the salary scales according to age, qualifications and experience with participation in F.S.S.U.

SALARY SCALES.

ENGINEER AND INFORMATION OFFICER

£1,240—£2,850

HOFFMANN RESEARCH FELLOW

£1,400—£1,850

DESIGN ENGINEER

£1,460—£2,500

Applications (three copies), which should include the names of three referees, should reach the Registrar and Secretary, The University, Leeds LS2 9JT, not later than 17th October, 1969.

TECHNICIAN required to work in University Department of Pharmacology on a research project connected with tissue transplantation and cancer. Experience of histological techniques essential. Salary according to experience. Application forms from Personnel Officer (Technical Staff FE/2) University College London, Gower St, W.C.1.

SENIOR 1 TECHNICIAN reqd. to take charge of Animal House, Royal Free Hospital Medical School. Must be I.A.T. Associate. Wide variety of research projects in progress. Salary scale £1,125–£1,450 + £90 London weighting. Apply stating age, quals. and exp. to School Secretary, 8 Hunter St., London, W.C.1.

UNIVERSITY OF ST ANDREWS

Department of Physiology

Applications are invited for the post of **LECTURER IN PHYSIOLOGY**, with preference to candidates having special interest in Pharmacology. Salary Scale £1,240–£2,850; F.S.S.U.; grant towards expenses of furniture removal. FIVE copies of applications, with the names of three referees, should be lodged by 20th September, 1969, with the Secretary of the University, College Gate, St Andrews, from whom further particulars may be obtained.

HUNTINGDON RESEARCH CENTRE RESEARCH OFFICERS

Graduates in biological sciences are required for participation in research work in the field of safety evaluation of drugs and other chemicals. Preference will be given to candidates who have an interest in mammalian systems, associated with a broader physico-chemical knowledge. They should have initiative and organising ability. Experience in the field of toxicology would be considered a definite advantage but is not essential. The commencing salary would be according to experience. Library and social facilities are good and four weeks' holiday will be granted per year.

Applications should be addressed to the Personnel Officer, Huntingdon Research Centre, Huntingdon, quoting reference PRN.

Communication System Architects



We apologise for adding to the jargon but the available tags such as Systems Engineers, Systems Analysts, etc., don't adequately express our requirements.

We require experienced engineers to engage in a wide variety of overall system studies for industrial, commercial, military and government customers. These studies embrace the widest aspects of communication including voice, vision and data. Tasks range from helping to formulate the requirement, proposing short and long term solutions, assessing options by cost-effectiveness and other techniques, to planning the implementation.

Typical projects currently in hand include such areas as:

- Design of national data networks
- Utilisation of communication satellites and their impact upon national and international networks
- Military communications
- Computer/Communication complexes for Command & Control Systems
- Message switching systems

- Comprehensive private networks for large industrial complexes
- Digital broadband microwave systems (free space and guided propagation)

Applications are invited from engineers, with several years' experience of telecommunications or computing applied to communication, to take part in, or in some cases to lead, these forward looking studies. Successful candidates will combine a thorough grasp of present-day communication practice with an imaginative attitude towards the future.

Enquiries would also be welcomed from more recently qualified applicants interested in working in the above fields.

Attractive salaries are available for the right staff. Why not come and talk to us? An appointment can be made by writing to or telephoning Mr. R. C. Leigh, Administration Executive, Plessey BTR Limited, Taplow Court, Maidenhead, Berkshire. Telephone: Maidenhead 23351.

PLESSEY



Under 25 with science 'A' levels? Become a Naval Engineer Officer and a B.Sc.

Within 4 years you could become a first class qualified engineer in the Navy. One of the most varied, challenging careers in engineering today.

You join as an officer and go to Dartmouth for a year's training, which includes 3 months at sea. Then you go to the Royal Naval Engineering College, where you read for a B.Sc. in electrical or mechanical engineering.

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working on anything from computers to guided missiles; or gas turbines to nuclear reactors.

As for responsibility, within a year or so of qualifying you could be the senior electrical engineer in one of our frigates.

But you're more than an engineer. You're a naval officer. The leader of a team. You travel. The company's great. Your professional status is high. And the sea life is yours.

Qualifications. Over 17 and under 25 when you join. 5 G.C.E. passes including Eng. Lang. and Chemistry at 'O' level, and Maths and Physics 'A' levels; or a good standard in a 4-subject O.N.C. together with a G.C.E. 'O' level pass in Eng. Lang. (For Scottish candidates, equivalent passes in the S.C.E.)

Entry. You join for 16 years (or till you're 38) on a pensionable commission, with good chances of a full career commission.

This could be the making of your career. Send us the coupon and we'll tell you more.



Name _____

Address _____

Date of birth _____

Qualifications _____

Captain W. J. Graham, R.N.,
Officer Entry Section (609EP2),
Old Admiralty Building, London, S.W.1.
Please send me details about training for a
commission in the Engineering Specialisation
of the Royal Navy.

RN
ROYAL NAVY

NATURAL ENVIRONMENT RESEARCH COUNCIL NATURE CONSERVANCY

Scientific Officer Class Vacancies

The Natural Environment Research Council has two Scientific Officer/Senior Scientific Officer vacancies in the Nature Conservancy.

Post 1.

Conservation Branch, Deputy Regional Officer, Midlands Region, based at Nottingham, with responsibility for the East Midlands including Nottinghamshire, Leicestershire and Rutland.

Post 2.

Conservation Branch, Deputy Regional Officer, South Wales Region based in Cardiff, with responsibility for regional affairs in South East Wales.

Duties.

Under the general direction of the Conservation Officer, England (Wales in the case of Post 2) Regional Officers and their Deputies are responsible for the scientific administration of their regions. Their duties include management of Nature Reserves; planning and executing biological surveys; liaison with Government Departments, local authorities, universities, land owners, farmers, naturalists' organisations and other bodies. They are expected to acquire an intimate knowledge of the flora and fauna, topography and land use history of the region.

Qualifications and Experience.

Applicants should have an honours degree in the biological sciences with relevant post-graduate experience.

Salary Scales.

Scientific Officer (under 29 on 31st December, 1969) £1,071-£1,827.

Senior Scientific Officer (normally at least 26 years and under 32 years at 31st December, 1969), £2,021-£2,491.

Initial appointment will be non-pensionable but there are prospects of a permanent and pensionable post.

FSSU arrangements already existing may be continued.

Application forms and further particulars may be obtained from Establishments (Scientific), The Nature Conservancy, 19 Belgrave Square, London, S.W.1. Closing date for the receipt of completed application forms, 3rd October, 1969. Please state clearly the post for which you are applying.

UNIVERSITY COLLEGE LONDON DEPARTMENT OF CHEMISTRY

Applications are invited for the posts of Technician and Junior Technician in the Organic Chemistry Teaching Laboratory. Applicants should have a sound knowledge of chemistry and experience in laboratory work. Salary: Technician £868 to £1,252, Junior £502 to £792. Application forms from Personnel Officer (Technical Staff CE/7), University College London, Gower Street, W.C.1.

DEMONSTRATOR in Amenity Horticulture required in Department of Horticulture for three years from 1st October. Applicants should have a good pass or honours degree in horticulture and interest in practical application. Duties include assistance with practical classes, plant propagation, nursery practice, landscape design and assistance with research. Salary scale £700 x 25 - £750 per annum. Apply in writing, quoting M.60, to Assistant Bursar (Personnel), University of Reading, Reading.

APPLICATIONS are invited from graduate chemists for a post at Research Officer level at the Tin Research Institute to carry out research on the chemistry of tin compounds. Publication of results encouraged. Salary dependent on age, qualifications and experience. (Minimum £1,075 per annum). Superannuation under F.S.S.U. Applications to the Director, Tin Research Institute, Fraser Road, Perivale, Greenford, Middlesex.

RESEARCH ASSISTANT, part or full time, experienced in sociological (psychological or psychiatric) research, required by scientist. Application with full details, Box D518, New Scientist.



Combustion Engineering

Pilkington Research and Development Department require additional staff for the Combustion Engineering Section.

The work of this section includes fuel utilisation, studies of combustion and combustion systems, waste heat recovery and high temperature measuring techniques.

Technologists are required with a degree in fuel technology, mechanical or chemical engineering of physics and experience and a real interest in one or more of these fields of work.

Technicians are required with an O.N.C. or H.N.C. in applied physics, mechanical engineering or fuel technology. Practical experience in instrument maintenance, oil fired and gas fired applications would be particularly useful.

The section is based at the R. & D. Laboratories at Lathom, near Ormskirk, in rural Lancashire and is part of a progressive research and development team in one of Britain's large and most successful companies which leads the world's glass industry.

PILKINGTON

Please write or telephone for an application form, quoting RD/11, to C.E.R. Fairburn, Group Personnel Department, Pilkington, Head Office, Prescott Road, St. Helens, Lancs. Telephone St. Helens 28882, extension 2129.



SCIENCE RESEARCH COUNCIL

Scientists and Engineers for administrative posts

Scientists and engineers with good honours degrees are required in London to help in managing the Council's research grants and post-graduate training award programmes. The work involves the critical examination of research proposals, servicing of committees, and liaison with universities and research establishments, with particular attention being paid to collaboration with industry. A broad appreciation of science and an interest in administration are essential. The appointments are expected to be in the 25-35 age range. Salaries, related to experience, on scales up to £2616. Non-contributory superannuation scheme and good promotion prospects. Further information and application form (to be returned completed by 3rd October) from:—

SCIENCE RESEARCH COUNCIL,

STATE HOUSE, HIGH HOLBORN, LONDON, W.C.1. (Tel. 01-242 1262 Ext 117)

Interviews will be held in State House during the week commencing 27th October, 1969.

UNIVERSITY OF LIVERPOOL Department of Computational and Statistical Science

Applications are invited for the post of Temporary Lecturer in Operational Research in the Department of Computational and Statistical Science. The appointment would be tenable for a period of two years.

The Department offers undergraduate and postgraduate courses in Numerical Analysis, Computer Science, Mathematical Statistics, and Operation Research, including a new postgraduate part-time course leading to a Diploma in Operational Research.

The main duties of the appointee will be associated with the Diploma course and applicants should have relevant postgraduate qualifications or experience.

Salary will be within the range £1,240-£2,045 per annum, according to qualifications and experience.

Applications stating age, qualifications and experience together with the names of three referees should be received not later than the 30th September by the Registrar, the University, P.O. Box 147, Liverpool L69 3BX, from whom further particulars may be obtained. Please quote Ref: RV/2847/NS.

MOREDUN RESEARCH INSTITUTE COMPARATIVE NEUROPATHOLOGIST

Applications are invited from veterinarians for the above vacancy in the department of Experimental Pathology. The department is the neuropathological reference laboratory to the Veterinary Investigation Service in Scotland. Facilities are available for histochemistry, electron and fluorescence microscopy and there is good experimental animal accommodation.

Previous experience is not essential. Appointment will be to within the Scientific Officer—Senior Scientific Officer grades. Salary scales from £1,071-£2,491 with entry according to age and qualifications. F.S.S.U. Superannuation.

Further particulars from The Secretary, Animal Diseases Research Association, 408 Gilmerton Road, Edinburgh EH17 7JH.

THE UNIVERSITY OF SHEFFIELD DEPARTMENT OF APPLIED MATHEMATICS AND COMPUTING SCIENCE

Applications are invited for a post of LECTURER in COMPUTING SCIENCE duties to begin as soon as possible. Salary in the range £1,240-£2,850 with F.S.S.U. provision. Further particulars from the Registrar to whom applications (4 copies should be sent by 1 October, 1969. Quot Ref. R49/H.

UNIVERSITY OF BIRMINGHAM

Department of Geology

Applications are invited for a post of doctoral RESEARCH FELLOW. A specific field of research is defined by preference will be given to candidates with interests in petrology, geochemistry, structural geology, stratigraphy or palaeontology.

Salary Scale: £1,240-£1,470 + F.S.S.U.

Applications (3) naming three referees by 29th September, 1969, to Assistant Registrar (S), P.O. Box 363, Birmingham 15. Please quote N.S.X.

TECHNICIAN required to work part time in the Department of Obstetrics and Gynaecology to assist on prole involving Radio-Isotopic Measurement of Blood Volume. Applicants should have A.I.M.L.T. or equivalent qualification. Applications in writing should be made to the Secretary, University College Hospital Medical School, University Street, London, W.C.1. quoting referer OBS 4.

UNIVERSITY COLLEGE OF NORTH WALES, BANGOR

Marine Science Laboratories

SCIENTIFIC OFFICERS

Applications are invited from candidates for two posts at Scientific Officer level on a research team which is shortly to be set up in these laboratories to investigate the biodegradation of oil in the sea and on beaches.

The successful applicants should hold a good honours degree and preferably have had some post-graduate research experience in one of the following disciplines:—

- (1) Organic chemistry
- (2) Biochemistry
- (3) Bacteriology
- (4) Protozoology.

The appointments are expected to be for five years in the first instance with a possibility of extension. The Salary scale will be £1,071-£1,827 per annum.

Applications (two copies), giving full details of age, qualifications and experience together with the names and addresses of three referees should be sent to the Secretary and Registrar, University College of North Wales, Bangor, to reach him not later than 30th September, 1969.

JUNIOR TECHNICAL OFFICER required for the Division of Microbiology at the National Institute For Medical Research. First class opportunity for young person to join a vigorous and expanding department. Preference will be given to candidates with a degree or equivalent qualifications. Starting salary on a scale initially up to £1,440 per annum with the usual fringe benefits. Apply, quoting our reference N.S. 13/2, to: The Personnel Officer, National Institute For Medical Research, The Ridgeway, Mill Hill, N.W.7. Telephone: 01-959 3666.

UNIVERSITY OF READING

PROFESSORSHIP OF PURE MATHEMATICS

Applications are invited for an additional Professorship of Pure Mathematics.

Further particulars may be obtained from the Registrar, (Room 208, Whiteknights House), The University, Whiteknights, Reading, RG6 2AH, by whom applications should be received not later than October 11, 1969.

DEPARTMENT OF HEALTH AND SOCIAL SECURITY

Senior Professional posts in the new Medicines Inspectorate

This Inspectorate is being formed under the Medicines Act 1968 for controlling the safety and quality of medicinal products.

Four appointments are to be made to initiate the non-medical inspection work under the Act. All will be based in London but varying amounts of travel will be involved.

One post will be as **PRINCIPAL INSPECTOR** and the others as **SENIOR INSPECTORS**. For both levels of entry candidates should preferably be graduates in one of the pharmaceutical sciences or a closely related field.

They must have had responsibility for in-process quality control in pharmaceutical manufacture (or equally relevant experience). *Additionally, for the Principal Inspector post, candidates must have had recent experience in overall charge of in-process quality control.*

The duties and salary ranges are:

PRINCIPAL INSPECTOR

...to assist in the initial planning of the Inspectorate and subsequently to supervise and direct non-medical professional and technical staff engaged on inspection duties under the Medicines Act mainly at pharmaceutical manufacturing premises throughout the United Kingdom.

Starting salary may be above the minimum of the scale £3975-£4525. Non-contributory pension.

SENIOR INSPECTORS

...to be mainly concerned with inspection duties in relation to the pharmaceutical industry. In due course they will also have supervisory responsibility for other non-medical professional and technical staff as the organisation is built up.

Starting salary may be above the minimum of the scale £3041-£3556 (£3205-£3750 from 1.1.70). Non-contributory pension.

Full details of these appointments may be obtained by writing to the Civil Service Commission, 23 Savile Row, London W1X 2AA, or by telephoning 01-734 6010 ext. 229 (01-734 6464 "Ansafone" service after 5.30 p.m.). At all times please quote S/7244/AQ. Closing date 1st October, 1969.



ELECTRICITY COUNCIL RESEARCH CENTRE

the Alchemist left a long time ago...

Today we call him a
CHEMICAL ENGINEER

At the Research Centre we have never tried to make gold by cooking sulphur, salt and mercury, and we don't wait for the phases of the moon, but we have developed several commercially interesting chemical ideas that we now want transmuted from the bench to the full scale industrial trial stage. For this we need a **CHEMICAL ENGINEER** to engineer processes for (a) continuous deposition of metal strip; (b) electrochemical methods of effluent disposal; (c) methods of direct polymer coating by glow discharge techniques. The appointment will be made in one of a series of salary bands having an overall maximum of £3,285.

Applications to:
David Page, Head of Personnel Services,
Electricity Council Research Centre,
Capenhurst, Chester

Ref: NS/205



The British Food Manufacturing Industries Research Association have the following two vacancies:

Assistant Librarian

Applicants should have some Library experience and a knowledge of the UDC system. A scientific background would be an advantage. Salary will be in the A.E.O./E.O. grades depending on age and experience.

Information Scientist

for the expanding Library and Information Section. Applicants should be Science Graduates with a good knowledge of German. Previous experience is not required, but interest in Information work is essential. Salary according to age and qualifications.

Please write to:

Secretary, BFMIRA, Randalls Road, Leatherhead, Surrey.



RESEARCH CENTRE FIELD RESEARCH ASSISTANT

We wish to appoint a Field Research Assistant to work with senior staff in the supervision of field trials in the animal health areas.

The man, preferably aged 25-35 would participate in all aspects of field trials, including selection of locality, basic design, supervision and collection of data. In addition a certain amount of clinical and laboratory examination would be involved.

The applicant should be educated to H.N.C. level or equivalent with specific training, if possible, in parasitology and bacteriology, and should have some experience in animal husbandry. The job would necessitate a varied amount of travelling in the United Kingdom and possibly in Europe and the applicant must be able to drive a car.

The Company is part of the Eli Lilly International Corporation and operates a first-class non-contributory pension scheme, B.U.P.A., and where applicable, financial aid in home removal. Salary will be based on age and experience.

Applications with brief details should be sent to: The Personnel Manager
LILLY RESEARCH CENTRE LIMITED
Erl Wood Manor, Windlesham, Surrey

Roads for the 70's-and beyond

Computer use in bridge & highway design

SECTION LEADER

(an additional
appointment)

A new Highways Engineering Computer Branch staffed jointly by Scientists and Engineers has been set up at the London headquarters of the Ministry of Transport. It will be concerned with highways and structures and will have access to practically all makes of computers. The work will involve the continuing appraisal of current methods and programs and the production of further and improved programs to meet the requirements of a comprehensive road network. The work will undoubtedly grow and those now joining the Branch will have the satisfaction of being in at the beginning of a new major project vital to the national economy. They will work closely with the Ministry's Engineering Intelligence and Bridges Design Divisions and the Road Research Laboratory. It is anticipated that there will be opportunities for interchange of staff to provide a broadly based career development. The appointment is for a scientist, normally

with 1st or 2nd class honours degree in disciplines which are related to problems of structures, who has worked in structural design in steel and concrete; or an engineer, normally corporate member of the ICE, IStructE or IMunE, with suitable experience. Good experience in the use of computers (including program writing) and a knowledge of major program languages are essential. Starting salary could be above the minimum of the scales:
£2724 to £3721 (grade of Principal Scientific Officer).
£3041 to £3556 (£3205 to £3750 from 1.1.70) (grade of Senior Engineer).
There is a non-contributory pension scheme and prospects of promotion should be good. Fuller details of these vacancies may be obtained by writing to the **Civil Service Commission, 23 Savile Row, London, W1X 2AA, quoting S/7212/AQ.**
Closing date 29th September, 1969.

NATIONAL PHYSICAL LABORATORY

Ministry of Technology
Teddington, Middlesex

TWO PHYSICISTS (graded Senior Scientific Officer/Scientific Officer) required in the Laboratory's Radiation Science Division to carry out fundamental research in the dosimetry of ionizing radiations. One project involves electron beam dosimetry by both chemical techniques and microcalorimetry, using initially a 2MV Van de Graaff and later a linear accelerator. A second project concerns the development of standards at protection levels for high energy gamma radiation.

Qualifications: 1st or 2nd class honours degree or equivalent in appropriate subject and, for S.S.O., at least three years' post-graduate experience. Previous experience in dosimetry is no essential but applicants should have an aptitude for the design and construction of experimental apparatus and instrumentation.

Salary: S.O. £1,146-£1,902; S.S.C. £2,096-£2,566. Prospects of permanent pensionable appointments.

Application forms from the Director at the above address. Please quote HC/2D/1848/F. Closing date: 30th September 1969.

ZOOLOGICAL SOCIETY OF LONDON

Wellcome Institute of
Comparative Physiology

Histology Technician required to assist in reproductive studies. Candidates must have had several years experience in histological techniques and possess a A.I.M.L.T. or equivalent qualification. Salary within the scale £775-£1,375 p.a. inclusive of London Weighting according to age, qualifications and experience. Write, giving full details, to the Establishment Officer, Zoological Society of London, Regent's Park, N.W. Quote ref: W.1.

Food Technologist

A well known Company in the Croydon area is looking for an ambitious young Food Technologist to take on the responsibility of developing new food and beverage products. Applications for this attractive vacancy are invited from men:—

- 1 Aged 25-30 with a University degree in Food Science/Technology or Chemistry.
- 2 Having 3-5 years' experience in the food industry in product development, technical research or technical management, preferably the former.
- 3 Possessing originality and capable of working without direct supervision.
- 4 Having the personality and breadth of interest to establish good working relationships with the Production and Marketing Departments of the Company and with appropriate outside bodies.
- 5 Having the ambition and capacity to undertake further study in an area of interest to the Company and the necessary management potential for proceeding to increasing responsibility in the technical field.

Consideration will be given to men worth about £1,800 and who are capable of proceeding to £3,000 within about 4-5 years, given suitable support.

The Company operates a Non-Contributory Pension Fund, has an Assisted Medical Scheme and provides canteen facilities. Assistance towards Removal Expenses will be considered. Apply under Confidential cover giving very comprehensive details of age, education, qualifications, experience, ambitions, present salary, etc. to Box D519, New Scientist.

SURFACE SCIENTIST

A vacancy has arisen for a scientist to study the chemistry and physics of metal and polymer surfaces. This work, which is of a fundamental nature but directly applicable to present products, will involve such areas as corrosion, the properties of oxide films, and their interaction with polymers.

The successful candidate will also be expected to contribute towards thinking on new Company products. Thus the position will be ideally suited to a man of postgraduate level with several years of relevant experience, but consideration will also be given to applicants of graduate level whose attributes enable them to make an immediate contribution to the work.

Extensive supporting facilities such as an electron microscope and access to a Stereoscan are available at our well-equipped Laboratories situated in pleasant surroundings within easy reach of London.

Applications should be addressed to:



The Personnel & Administration Manager,
Wilkinson Sword
(Research) Limited,
Colnbrook, Slough, Bucks.

UNIVERSITY OF OXFORD

Appointment of Senior Research Officer in the Nuffield Laboratory of Ophthalmology

The University proposes to appoint a Senior Research Officer in the Nuffield Laboratory of Ophthalmology. Salary according to age on the scale £1,240 to £3,120 per annum, with FSSU.

Topics currently being studied in the Laboratory include the enzymes and proteins of the normal and cataractous lens and the experimental production of lens opacities, but candidates should not feel restricted to these aspects of the scientific study of the eye.

Applications (5 copies, or one from overseas candidates) stating age, qualifications and experience, with list of publications and names and addresses of two referees should reach the Administrator, Nuffield Laboratory of Ophthalmology, Walton Street, Oxford OX2 6AW (from whom further particulars may be obtained) by 18 October 1969.

THE HATFIELD POLYTECHNIC RESEARCH ASSISTANT in ASTRONOMY

Applications for an appointment as a research assistant are invited from Graduates in Astronomy, Physics or Electronic Engineering having a special interest in any of the following topics.

- (1) Infra-red instrumentation
- (2) Data recovery
- (3) Photo-electric photometry

Further details from the Academic Registrar, The Hatfield Polytechnic, Hatfield, Herts. Quote ref: 232/NS

School Leavers for Research

If you have recently had success in G.C.E. "O" or "A" level examinations and are wishing to embark on a scientific or technical career, we should like to hear from you.

We are interested in young men and women with passes in physics, chemistry or mathematics who are anxious to gain further qualifications and are eager for the challenge of a career in a rapidly expanding industry.

We offer attractive salaries and conditions, run an excellent Further Education Scheme and enable you to study by means of day release facilities at local techs.

PILKINGTON

Write in the first instance to: Terry Henshall, Pilkington Research & Development Laboratories, Lathom, Ormskirk, Lancashire, or ring Mrs. S. A. Lancashire on Ormskirk 73801 for an application form.

THE UNIVERSITY OF SUSSEX SCIENCE POLICY RESEARCH UNIT

A RESEARCH FELLOWSHIP is available for two years on a project concerned with the effects on human safety and the natural environment of industrial activity, with special regard to innovation.

Candidates may have a degree either in Science, Engineering or Economics. Experience in the assessment of hazards and/or statistics would be advantageous.

Salary in the range £1,240-£2,505 plus F.S.S.U.

Application forms and further details may be obtained from the Establishment Office, Essex House, University of Sussex, Falmer, Brighton, BN1 9QQ, quoting Ref. 935/2. Closing date for applications 26th September, 1969.

UNIVERSITY COLLEGE, CARDIFF

Applications are invited for the post of Lecturer in Mechanical Engineering Design. Applicants should possess a good Honours or Higher Degree and should have had design experience in industry for some years.

The appointment will commence on November 1st, 1969, or as soon after as possible.

Salary: £1,240×£115-£2,045 Bar × £115-£2,850.

Further particulars may be obtained from the Registrar, University College, Cathays Park, Cardiff, to whom two applications with the names of three referees should be submitted by 4th October, 1969.

E. R. EVANS, Registrar.

NORTHERN POLYTECHNIC HOLLOWAY, LONDON, N.7.

Department of Chemistry

The Governing Body invites immediate applications for the post of LECTURER GRADE II in ORGANIC CHEMISTRY. Candidates will be expected to teach to Honours Degree level and to undertake research in some aspect of organic chemistry. Salary scale (under review) £1,725-£2,280 plus £85 London Allowance.

Apply for further particulars and form of application.

R. H. CURRELL, Clerk.

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LECTURES, MEETINGS AND COURSES

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LIVERPOOL REGIONAL COLLEGE OF TECHNOLOGY

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A SYMPOSIUM FOR TEACHERS
ON

PRACTICAL BACTERIOLOGY
To be held on 18th October
1969

This practical course is designed to cover basic techniques of bacteriology together with the bacteriology of water, soil and milk. The methods offered use only simple equipment and are suitable for the school laboratory.

Members are asked to select one subject only as each of the four sections is designed to be a complete course in itself.

Fee £3.0.0

Further details and application forms may be obtained from Dr. G. E. Anderson, Department of Chemistry and Biology.

SIR JOHN CASS COLLEGE

Department of Physics

**PART-TIME
M.Sc. COURSES**

M.Sc. in Vacuum Science and the Physics of Thin Films and Solid Surfaces.

This is a two-year day and evening course, or a two- or three-year evening course comprising lectures, tutorials, practical projects and the preparation of a critical survey, for the M.Sc. degree of the C.N.A.A.

The lectures will be held on Wednesday evenings starting at 6 p.m. on Wednesday, 1st October, 1969.

Closing date for applications 22nd September, 1969. The lectures may be taken as a post-graduate course without registering for the M.Sc.

All enquiries to:

**The Secretary, Department of Physics
Sir John Cass College
Jewry Street, London E.C.3. Tel: 01-481 8321**

NORTHERN POLYTECHNIC Holloway, London, N.7. DEPARTMENT OF CHEMISTRY

M.Sc. in Inorganic Polymers

This College offers a two or three year course of lectures and practical work held in the evenings only, leading to the degree of Master of Science of the Council for National Academic Awards.

Inorganic and semi-inorganic macromolecules will be studied in the context of inorganic and polymer chemistry. The course is intended for students possessing an Honours Degree in chemistry or an equivalent qualification.

Further information from the Head of Department.

NORTHERN POLYTECHNIC Holloway Road, London, N.7.

DEPARTMENT OF PHYSICS
Postgraduate Evening or
Part-time Courses

Session 1969/70

Lecture courses lasting 2 terms or more:
Electrical Discharges in Gases, Tuesdays 6-9, Fridays 6-9 or Tuesdays 2-5 & 6-9 Commencing 7th October 1969.

The Physical Basis of Electronics, Mondays 6-9, Thursdays 6-9 or Tuesdays 10-1, 2-5 & 6-9, Thursdays 6-9. Commencing Tuesday, 30th September or Monday, 6th October, 1969.

These lectures are open to any students able to profit and they are designed to give a good background to industrial work. Suitably qualified students, adding further study and practical work, can proceed to the degree of M.Sc.

Lecture courses lasting 1 term:
The Physics of Magnetic Recording, Tuesdays 6.30-9. Commencing 14th October, 1969.

Recent Developments in Counting Circuits, Fridays 6.30-8. Commencing 10th October, 1969.

These lectures are open to any workers in appropriate fields.

Apply for further details to the Head of the Department of Physics.

BOROUGH POLYTECHNIC

**M.Sc. COURSE IN
EXPERIMENTAL
NUCLEAR PHYSICS**

A one year full-time or two/three year part-time course leading to the degree of M.Sc. of the C.N.A.A. is available at the Borough Polytechnic. It is designed to cover the fundamentals of nuclear physics with special reference to the experimental techniques employed.

The course consists of lectures and laboratory work, followed by a research project which in some cases may be carried out in industry.

Further information is available from:

**The Secretary,
Borough Polytechnic,
Borough Road, London S.E.1**

BRITISH Society for Social Responsibility in Science. Dr. J. G. Westerman and Dr. S. Lal will speak on 'Man and Medicine in the 21st Century' at The Black Horse, Rathbone Place, W.C.1. at 8.0 p.m. on Tuesday 16th September. Membership enquiries at the meeting or to BSSRS, 42 Great Russell St., London W.C.1.

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For further information please contact J. J. Seymour, Mullard Research Laboratories, Redhill, Surrey. Telephone: Horley 5544. Telex 264341.

STUDENTSHIPS

THE UNIVERSITY OF MANCHESTER INSTITUTE OF SCIENCE AND TECHNOLOGY

RESEARCH STUDENTSHIP

Applications are invited for graduate research in an appropriate field for Research Studentships available in the Thermodynamics and Fluid Mechanics Division of the Department of Mechanical Engineering. The Research work will be concerned with heat release in diesel engines and two-stage turbocharging. The successful applicants will be able to work for the Degrees of M.Sc. or Ph.D. The Studentships will carry the same value as S.R.C. Studentships.

Enquiries should be addressed to Professor R. S. Benson, University of Manchester Institute of Science and Technology, P.O. Box 88, Manchester M60 1QD, from whom application forms can be obtained.

ROYAL HOLLOWAY COLLEGE

(University Of London)

Englefield Green, Surrey.

BIOCHEMISTRY DEPARTMENT

Applications are invited from chemists and biochemists for a postgraduate studentship in the Department of Biochemistry to work on the control of microbiological blackening of cereals. The studentship is valued at £550 year.

Applications, together with names and addresses of two referees, should be sent to the College Secretary as soon as possible.

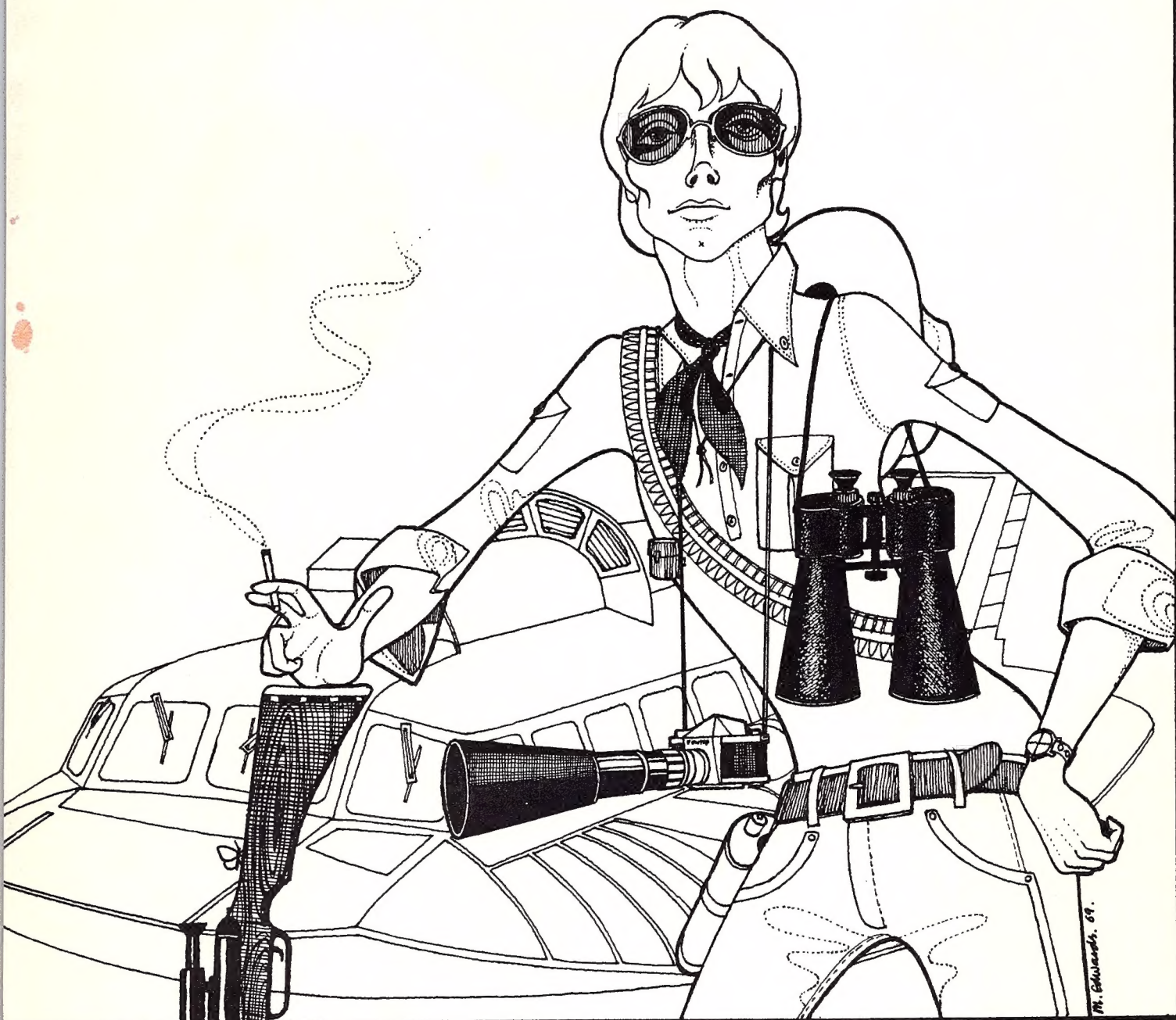
UNIVERSITY OF BIRMINGHAM

Department of Minerals
Engineering

Applications are invited for a RESEARCH STUDENTSHIP, value £53 p.a. plus fees, for work on solvent extraction of metal ions. Candidates should have a good honours degree in chemistry or equivalent and would be expected to work towards a higher degree.

Applications (2) naming two referees by 20th September to Head of Department of Minerals Engineering, University of Birmingham, P.O. Box 363, Birmingham, 15.

Dr Livingstone, I presume?



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